NEW YORK FISH AND GAME JOURNAL

VOLUME 19 January, 1972 Number 1

EXPERIMENTAL TRANSFER OF SARCOPTIC MANGE FROM RED FOXES AND WILD CANIDS TO CAPTIVE WILDLIFE AND DOMESTIC ANIMALS [1]

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ABSTRACT

Sarcoptic mange of red fox or wild canid origin was successfully transmitted to captive red foxes, gray foxes, dogs and wild canids, but only transitory infestations resulted in the gray fox. No mange infestations resulted in raccoons, striped skunks, opossums, cats, chipmunks, gray squirrels, woodchucks, rats, mice or a cottontail rabbit contaminated with sarcoptic mites of red fox origin. Since sarcoptic mange mites from red foxes are readily interchanged among red foxes, dogs and wild canids, it appears that red foxes are parasitized by the *Sarcoptes scabiei* var. *canis* of dogs.

In July 1969, the senior author confirmed a serious outbreak of sarcoptic mange among red foxes (*Vulpes fulva*) that, a short while before, had been brought into captivity at the Wildlife Research Laboratory at Delmar (N. Y.). At the same time, red foxes with sarcoptic mange were being submitted from the Adirondack and Catskill regions for examination. However, little was known about mange in this species.

The first case of sarcoptic mange reported in a red fox from New York occurred in 1937 (LeDune, 1937). Goble (1945) did not mention sarcoptic mange in his discussion of red foxes in New York. Prior to July 1969, most diagnoses had been made by superficial examination

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-35-R. The authors wish to acknowledge the assistance of Dr. John Debbie, Nancy Churchill, Forrest Mance, Gary Will and George Teidman during the course of the research and credit the photographs to Nicholas Drahos (Figure 1), Peter Scofield (Figures 2-6) and Walter Fogg (Figure 7).

without microscopically checking for mites; no studies of the course of the infestation, pathogenicity or host specificity of the sarcoptic mites of red foxes had been undertaken.

Elsewhere, Pryor (1956) reported on the superficial examination of 60,846 red foxes and 55,706 gray foxes (*Urocyon cinercoargenteus*) for mange in Pennsylvania. Of these, 780 red foxes and two gray foxes were diagnosed as mangy. Although some of the red foxes were examined microscopically for mites, neither of the gray foxes was so examined to confirm the infestation. Studies indicated that sarcoptic mange was responsible for decreases in red fox populations in parts of Wisconsin during 1967-68; however, no cases were discovered in gray foxes, even though they were abundant in parts of the state (Trainer and Hale, 1969). This information suggested that the gray fox is less susceptible to mange than is the red fox.

It was decided that experimental transfers of sarcoptic mange mites from red foxes and wild canids to captive wildlife and domestic animals would help answer the questions on the course of infestation, pathogenicity and host specificity. The work was carried on at the Wildlife Research Laboratory at Delmar.

PROCEDURES

Attempts were made to transfer sarcoptic mange from infested red foxes or a wild canid to 16 red foxes, five gray foxes, four dogs (*Canis familiaris*), two wild canids (*Canis* sp.), two raccoons (*Procyon lotor*), two striped skunks (*Mephitis mephitis*), four opossums (*Didelphus marsupialis*), four cats (*Felis domesticus*), four chipmunks (*Tamias striatus*), two gray squirrels (*Scuirus carolinensis*), two woodchucks (*Marmota monax*), four rats (*Rattus norvegicus*), four mice (*Mus musculus*) and one cottontail rabbit (*Sylvilagus floridanus*) that were not infested.

The term "wild canid" is used in this paper for a coyote-like canid that has some dog characteristics derived through hybridization. In New York, these animals seem to be less coyote-like in the southern parts of the state, where dog densities are higher and hybridization is more likely to occur, than in the northern region. They fit the general description of wild canids in New Hampshire (Silver and Silver, 1969) which were designated eastern coyotes (*Canis latrans* var.). However, until taxonomic and behavioral studies are carried out on those in New York, we feel that no specific name for them is warranted.

Each experimental red fox and gray fox was kept in an individual house with attached wire run within an isolated, fenced enclosure. The control foxes were kept in a different enclosure, each in an individual house similar to those of the experimental animals. Each group was cared for by a different individual, so that accidental

transfer of mites would not occur. The individual assigned to the experimental animals wore clothing used only when taking care of these foxes. Separate food supplies and utensils were maintained for the two groups.

The dogs and wild canids were kept in pens isolated from the foxes. The remaining animals were kept in separate cages, isolated from other species in the study, or in isolation rooms in the Laboratory.

The captive carnivores were fed Purina or Casco Dog Chow ad libitum, supplemented with venison from road-killed deer. Water was available continuously.

All the animals were examined grossly for mange lesions prior to experimentation. On three separate occasions, prior to mite transfer attempts, their skins were scraped with a dull scalpel, and the scrapings were mounted in Berlese fluid and examined microscopically for mites to check for possible existing sarcoptic infections.

The experimental animals were contaminated with sarcoptic mites taken from red foxes found dead in Albany and Onondaga Counties or from a mangy wild canid found dead in Essex County. Scrapings from the source carcasses were mounted in Berlese fluid, and the mites were identified as *Sarcoptes scabiei*. Lots of approximately 500 mobile sarcoptic mites were removed from the carcasses and placed in vials. The vials of mites were then taken to the experimental pens or isolation rooms, where the mites were removed and mixed into the hair of the mid-back region on the test animals. Later, sarcoptic mange mites which developed in the experimental animals were transferred to other experimental animals in an attempt to infest them.

Following contamination with sarcoptic mites, each experimental animal was observed daily for signs of mange; at no longer than 1-week intervals, scrapings were taken, mounted in Berlese fluid and examined microscopically for mites.

RESULTS

No experimental infestations with sarcoptic mites of red fox origin were established on the raccoons, striped skunks, opossums, cats, chipmunks, gray squirrels, woodchucks, rats, mice or cottontail rabbit. No mites could be found in the skin scrapings taken a week following contamination, and none was found in scrapings taken over a minimum of 2½ months of observation. The opossums, skunks, raccoons and one cat were observed for 6 months following exposure.

DOGS AND WILD CANIDS

In April 1970, two 12-week-old dogs (litter mates, a male and female of a Labrador-Blue Tick cross) and two approximately 12-week-old wild canids (a male and female of a litter taken in Greene County)

were contaminated with sarcoptic mites from a mangy fox from Onondaga County. Eleven days after exposure, the dogs and wild canids developed red papules (3-12 millimeters), primarily on the hind legs with some present on the nose, ears, back, abdomen and front legs. Skin scrapings yielded low numbers of mites and numerous eggs. Crusted lesions took the place of the papules, and the mange progressed slowly for 26 days after exposure. At 26 days, the lesions were still mainly on the hind legs and hocks; Figure 1 shows mange lesions on the hind legs of one of the dogs at this time. From the 30th to the 34th days, the mange became severe (Figures 2 and 3). Large amounts of hair were lost from the hind legs, forelegs and abdomen. Patches of hair were lost from around the dogs' eyes, cheeks, ears and snout, and the encrusted lesions began to coalesce. The mange was more severe in the males than in the females. By the 34th day, the male wild canid had lost patches of hair from its tail and rump (Figure 4), and the rump and root of the tail became a mass of encrusted lesions, torn and bleeding from the animal's scratching. Both the male and female wild canid had thinning of the hair on the hind legs and flaking skin. Numerous sarcoptic mites, eggs and mite fecal material were present in the scrapings taken from the lesions on both species. Mites were transferred from these animals to captive red foxes that subsequently developed mange.

On the 35th day, the mangy dogs and wild canids (17 weeks old) were treated with 0.1 per cent lindane solution; the male wild canid was acutely ill from the mange. A week later, the raw lesions on the animals had healed, and a natural skin color had returned. Scrapings yielded some pieces of mite exoskeletons, but no intact mites were found. Five weeks following the lindane treatment, the animals were completely recovered with no evidence of their bout with mange. Skin scrapings were negative for sarcoptic mites.

The approximately 23-week-old wild canids that had just recovered from the mange and two 23-week-old dogs (from the same litter as the dogs just discussed) were contaminated with mites (*S. scabiei*) from a red fox found dying of mange in Albany County. Five days later, the dogs showed a few papules on their abdomens and the hocks of the hind legs, but many scrapings were necessary to demonstrate sarcoptic mites. At 13 days, lesions became evident on the ears and hocks of the hind legs of the wild canids, but mites were present in low numbers in the scrapings. At 38 days, the mange had progressed over all of the hind legs and along the dorsal aspect of the tails of the wild canids. The ears had become encrusted, and the animals were continuously scratching the afflicted regions of their integuments. The mange lesions were similar on the dogs except on their noses and the area around their eyes, which were developing encrusted areas. The wild canids did

Figure 1. Sarcoptic mange lesions on the hind legs of a 16-week-old dog.

Figure 2. Sarcoptic mange lesions on the head and front leg of a 17-week-old dog.

Figure 3. Sarcoptic mange lesions on the medial aspect of the hind legs of a 17-week-old dog.

Figure 4. Sarcoptic mange lesions on the tail and rump of a 17-week-old wild canid.

not appear to have gained any immunity to sarcoptic mange from their first infestation. Upon microscopic examination, scrapings taken from both species at 38 days showed numerous sarcoptic mites, eggs and mite feces. The animals were treated with 0.1 per cent lindane, and no relapse occurred during 6 months of observation following the treatment.

Two litter-mate dogs and two litter-mate wild canids, held as controls, remained negative for mange throughout the study period.

RED FOX

Eight adult red foxes were contaminated with sarcoptic mange mites from the Onondaga County red fox, six with mites from the Albany County red fox and two with mites from the wild canid from Essex County. However, the course of the infestation was somewhat different than in the experimental dogs and wild canids. All of the 16 foxes succumbed over a period of 2 to 4 months (average, 3 months) following contamination.

The general course of infestation was that an occasional sarcoptic mite could be found in the skin scrapings 7 to 13 days following contamination, but mange lesions were not evident. From 20 to 30 days after contamination, skin flaking occurred on the hind legs, particularly in the region of the hocks and sometimes on the abdomen and flanks. Mites were demonstrated in nearly every scraping from affected regions, but their density was low. During this period, the mange spread slowly over the body. The flaking skin areas changed to lesions leaking exudate, and the skin became wrinkled and crusted. A sickening aromatic odor, characteristic of sarcoptic mange, became apparent. After 2 or 3 months, the foxes had necrotic skin. Their eyes became squinted as a result of invasion of the eyelids by the mites. Scrapings of mange lesions from all parts of the body yielded increasing numbers of sarcoptic mites, eggs and mite feces as the infestation progressed, until, terminally, they were extremely abundant. During late stages of infestation, the foxes scratched and bit the mangy regions; however, in the dogs and wild canids, this was an early characteristic of infestation. Terminally, the red foxes, although weak, continued to have good appetites.

GRAY FOX

Five adult gray foxes were contaminated with approximately 500 sarcoptic mites from the Onondaga County red fox. No infestation resulted, and no sarcoptic mites were recovered in scrapings. However, eight red foxes, contaminated at the same time and with mites from the same source, all developed sarcoptic mange and died from it.

Three months after the first contamination of the gray foxes with mites of red fox origin, a second attempt was made. This experimental contamination was massive; a heavy dose of thousands of sarcoptic mites from the Albany County red fox was applied. Twelve days later, very low numbers of sarcoptic mites were found in scrapings from the hind legs of two of the foxes. The infestation remained localized on the hind legs (Figures 5 and 6) for 3 months. The mites caused slight scaling and flaking of the skin and a little hair loss, but the infestation could have been easily overlooked. Skin scrapings of the scaled region of the hind legs yielded small numbers of mites and eggs. No mange odor developed, and the lesions did not shed exudate. Skin scrapings containing sarcoptic mites were taken from the gray foxes and placed on a mite-free red fox that subsequently developed sarcoptic mange and died from it. By the fourth month, the lesions on the leg had completely healed without being treated, the hair had returned and sarcoptic mites could not be demonstrated in repeated scrapings.

Three of the five gray foxes never showed mange lesions, nor were sarcoptic mites recovered from them following the two experimental contaminations. The two that demonstrated infestations did not have relapses of mange or show sarcoptic mites in their skin scrapings for the 3 months they were observed after the disappearance of experimental infestation.

DISCUSSION

The demonstration that dogs and wild canids can be readily infected with mites (*S. scabiei*) of red fox origin indicates that mangy red foxes and wild canids are a potential source of sarcoptic mange infections for domestic dogs. Hunting dogs and dogs in rural areas frequently come in contact with weakened, mangy red foxes or wild canids. When contact is known to have occurred, exposed dogs should be watched for mange lesions and taken to a veterinarian for diagnosis and treatment. The sarcoptic mites of red fox origin seemed very pathogenic to the dogs and wild canids studied; if these animals had not been treated, the infestation probably would have been fatal.

Sarcoptic mites from the wild red foxes and wild canids were extremely pathogenic to captive red foxes as evidenced by the fact that, of the 16 red foxes exposed, all died of sarcoptic mange. LePage (1962) stated that animals in good health and condition are rather resistant to sarcoptic mange. However, over 150 red foxes, exclusive of those used in the mange experiments, have been maintained at the Wildlife Research Laboratory in similar pens and on the same diet. They have successfully reproduced and have had only a 2 per cent mortality rate caused by factors other than mange. Therefore, it is felt that the red foxes involved in the mange study were well adapted to caged condi-

Figure 5. Hair thinning on the hind leg of a gray fox 2 months after experimental infestation with sarcoptic mites of red fox origin.

Figure 6. Mange lesions on the hock of a gray fox 2 months after experimental infestation with sarcoptic mites of red fox origin.

Figure 7. A red fox that died of mange in Dutchess County (N.Y.) during November 1970.

tions, and that red foxes acquiring sarcoptic mange in the wild suffer the same fate as did the experimental animals. At all seasons of the year, the terminal appearance of wild, mangy red foxes (Figure 7) submitted to the Laboratory has been very similar to that of the experimental, mangy foxes. However, wild red foxes with sarcoptic mange may die sooner than did the experimental animals because, in their weakened condition, hunting and acquiring food may be more difficult, and they may suffer from exposure during the cold months due to the hair loss that accompanies mange.

The difficulty in infecting the gray foxes with sarcoptic mange mites of red fox origin, even after massive contamination, and the transitory nature of the infestations indicate that the gray fox is a poor host for mites of the species *S. scabiei*. No confirmed cases of sarcoptic mange in wild gray foxes in New York are known, nor are any confirmed cases known from other states. However, the implication from these experiments is that cases of sarcoptic mange in gray foxes could occur rarely. Probably, mite populations would be low and these cases could be overlooked easily, but, in some gray foxes, particularly weakened ones, sarcoptic mange might become severe

The inability of sarcoptic mange infestations to develop and the

absence of sarcoptic mites in the skin scrapings taken following contamination indicate that the raccoons, striped skunks, opossums, cats, chipmunks, gray squirrels, woodchucks, rats, mice and cottontail rabbit were inhospitable hosts for the strains of sarcoptic mites used in these experiments.

Sarcoptes scabiei occurs in a variety of mammalian hosts including man. Although the mites from these species appear morphologically identical, there are biological or physiological races that seem specific to given hosts (LaPage, 1962). The sarcoptic mites of red foxes appear morphologically identical to *S. scabiei* of dogs. Thus, since these mites are readily interchanged among red foxes, dogs and wild canids, it appears that red foxes are parasitized by the *S. scabiei* var. *canis* of dogs.

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ARSENIC CONTENT OF FISH FROM NEW YORK STATE WATERS [1]

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ABSTRACT

A survey of 471 fish sampled in 1969 from 49 New York State waters for total arsenic content is presented. Arsenic levels ranged up to about 0.5 ppm with fish from Lake Ontario, Canandaigua Lake and the Hudson, St. Lawrence and Salmon Rivers being relatively higher. Larger fish generally contained higher arsenic concentrations. Arsenic did not appear to be cumulative with increasing age in lake trout ranging from 2 to 11 years old.

Arsenic is found ubiquitously in nature in small amounts. Some occurs in the elemental form or as arsenides or oxides, but it exists more often as metal arsenites and as pyrites. Its major use has been in agriculture for controlling insects, weeds and aquatic plants, and this use constitutes one source of water contamination. Another source may be detergents and enzyme presoaks in which arsenic has been recently reported as an impurity at levels up to 70 ppm (Angino et al., 1970). Effluents from industry and mining wastes containing arsenic also pollute water.

Arsenic is most often present in natural waters as arsenate or arsenite. An excellent survey of metal concentrations in United States waters has been prepared (Kopp and Kroner, 1970). Between 1962 and 1967 these workers reported arsenic levels up to 336 ppb in Lake Erie at Buffalo, N.Y. and concentrations ranging from 15 to 58 ppb in the St. Lawrence River at Massena, N.Y. Arsenic was not detected in the Hudson River below Poughkeepsie, the last New York site surveyed. Arsenic may concentrate in the tissues of organisms, and therefore even a low water concentration may be of concern (Federal Water Pollution Control Administration, 1968). Arsenic may exert its toxic effect in biological systems by substituting for phosphorus and becoming an antimetabolite. Gilderhus (1966) reported the effects on bluegills

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[1] The authors thank W. D. Youngs of the Cornell Conservation Department for collecting the lake trout of various ages from Cayuga Lake.

(*Lepomis macrochirus*) in water containing low levels of sodium arsenite.

The New York State Department of Environmental Conservation has maintained an active statewide fish sampling program to survey fish for pesticide residues and industrial toxicants and to furnish material for other studies. In the work reported here, representing an

Table 1. Recovery of Arsenic from Fish

Species	Arsenic added (ppm)	Recovery (per cent)
Catfish	0.2	97
Coho salmon	0.2	70
Lake trout	0.2	60
	0.4	70, 60
	0.6	69, 78
	0.8	67, 73
	1.0	80
Lake whitefish	0.2	64, 80
Smallmouth bass	0.2	67, 72, 67, 67
White bass	0.2	67

Table 2. Species of Fish Analyzed for Arsenic

Common name	Scientific name
Black crappie	*Pomoxis nigromaculatus*
Bowfin	*Amia calva*
Brook trout (speckled trout)	*Salvelinus fontinalis*
Brown trout	*Salmo trutta*
Bullhead	*Ictalurus* sp.
Burbot	*Lota lota*
Carp	*Cyprinus carpio*
Catfish	*Ictalurus* sp.
Chain pickerel	*Esox niger*
Cisco	*Coregonus artedii*
Coho salmon	*Oncorhynchus kisutch*
Freshwater drum	*Aplodinotus grunniens*
Gizzard shad	*Dorosoma cepedianum*
Goldfish	*Carassius auratus*
Lake trout	*Salvelinus namaycush*
Lake whitefish	*Coregonus clupeaformis*
Largemouth bass	*Micropterus salmoides*
Muskalonge	*Esox masquinongy*
Northern pike	*Esox lucius*
Perch	*Perca* sp.
Rainbow trout	*Salmo gairdneri*
Rock bass	*Ambloplites rupestris*
Smallmouth bass	*Micropterus dolomieui*
Splake (brook trout X lake trout)	
Striped bass	*Morone saxatilis*
Sturgeon	*Acipenser* sp.
Walleye pike	*Stizostedion vitreum vitreum*
White bass (silver bass)	*Roccus chrysops*
White sucker (sucker)	*Catastomus commersoni*

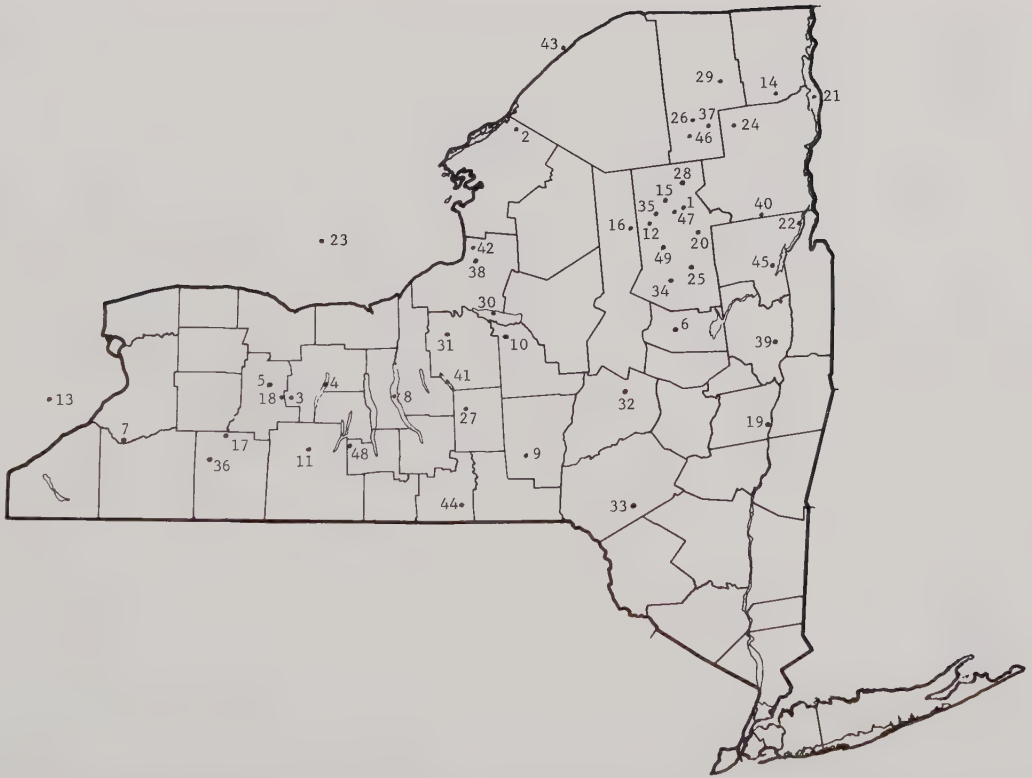

Figure 1. Approximate location of the waters from which the fish analyzed were taken. Numbers refer to the waters as listed and named in Table 3.

Table 3. Residues of Total Arsenic in Fish from Various New York State Waters in 1969

Tag number	Water *	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
6R6527	Blue Mountain Lake (1)	Bullhead-catfish	Female	28.4	0.379	nd
6R6528	"	"	Male	28.9	0.377	nd
6R6529	"	"	Female	27.9	0.378	0.1
6R6522	"	Rainbow trout	Female	33.0	0.393	0.08
6R6521	"	"	Male	33.8	0.173	nd
6R6526	"	Smallmouth bass	Male	28.2	0.275	0.03
22BL-4	Butterfield Lake (2)	Bowfin	Male	55.9	1.702	0.04
24BL-4	"	Bullhead-catfish	Female	32.2	0.669	nd
23BL-4	"	"	Female	33.0	0.685	nd
25BL-4	"	"	Female	32.0	0.680	nd
19BL-4	"	Largemouth bass	Female	34.8	0.657	0.04
21BL-4	"	"	Male	34.5	0.626	0.03
20BL-4	"	"	Female	33.0	0.573	0.03
9BL-4	"	Northern pike	..	..	..	0.04
8BL-4	"	"	..	..	..	0.04
10BL-4	"	"	..	..	..	0.04
7BL-4	"	"	..	..	..	0.03
14BL-4	"	Rock bass	Male	22.9	0.263	0.04
15BL-4	"	"	Male	22.2	0.277	nd
11BL-4	"	Smallmouth bass	..	..	..	0.04
12BL-4	"	"	..	..	..	0.04
28BL4	"	Sucker	Male	38.6	0.916	nd
26BL-4	"	Walleye pike	Male	55.9	1.753	nd
29BL-4	"	"	Male	47.3	1.071	nd
27BL-4	"	"	Male	48.7	1.268	nd
J6220	Canadice Lake (3)	Bullhead-catfish	..	35.0	0.574	0.06
J6295	"	Lake trout	Male	76.8	4.855	0.18
J6293	"	"	Male	47.8	1.246	0.08
J6228	"	Pickerel (chain)	Female	46.0	0.699	0.06
J6222	"	"	Female	40.7	0.471	0.06
J6225	"	Rainbow trout	..	29.2	0.284	0.09
J6296	"	"	Male	30.5	0.370	0.06

TABLE 3. (*continued*)

Tag number	Water *	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
J6226	"	"	..	27.4	0.243	0.06
J6297	"	"	Male	32.5	0.430	0.06
J6212	"	Rock bass	Male	21.8	0.248	0.04
J6210	"	Smallmouth bass	Male	36.1	0.751	nd
J6211	"	"	Male	28.4	0.386	0.04
J6291	"	"	Male	29.2	0.409	0.09
J6290	"	"	Female	33.6	0.603	0.07
J6292	"	"	Female	29.2	0.378	0.03
J6288	Canandaigua Lake (4)	Brown trout	Male	56.7	2.595	0.15
J6287	"	Lake trout	Male	55.2	1.821	0.12
J6286	"	"	Male	52.6	1.545	0.13
J6231	"	"	Male §	44.4	0.722	0.08
J6167	"	Largemouth bass	Male	28.7	0.370	0.04
J6162	"	Smallmouth bass	Female	28.7	0.359	0.15
J6102	Conesus Lake (5)	Black crappie	..	..	..	0.16
6R6192	Caroga Lake (6)	Smallmouth bass	Female	40.9	1.295	0.03
2F1201	Cattaraugus Creek (7)	Coho salmon	Male	41.6	0.683	0.08
2F1202	"	"	Male	40.2	0.588	0.08
2F1203	"	"	Male	37.9	0.588	0.10
2F1204	"	"	Female	54.4	1.77	0.06
2F1205	"	"	Female	56.8	2.09	0.06
2F1206	"	"	Female	61.0	2.19	0.10
2F1207	"	"	Female	60.2	2.23	0.07
2F1208	"	"	Female	63.0	3.04	0.06
2F1209	"	"	Female	64.0	3.00	0.07
2F1301	"	"	Male	33.2	0.454	0.06
3-CL-2	Cayuga Lake (8)	Largemouth bass	..	15.25	..	0.10
3-CL-1	"	"	Male	31.7	0.621	0.16
CAY-1	"	Pickerel (chain)	..	..	..	0.03

TABLE 3. (*continued*)

Tag number	Water *	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
CAY-2	"	"	..	..	..	0.08
CAY-3	"	"	..	..	..	0.09
salmon	"	Salmon	..	..	..	0.25
3-CHR-1	Chenango River (9)	Smallmouth bass	Female	22.2	0.168	0.06
3-ChR.Ch.-8	"	"	Female	30.5	0.436	0.15
3-ChR.-3	"	"	Female	27.9	0.343	0.07
3-ChR.-5	"	"	Male	34.9	0.550	0.12
3-CHR-2	"	"	Imm	24.8	0.198	0.07
3-CHR-4	"	"	Male	28.6	0.295	0.06
3-CH-1	Chittenango Creek (10)	Brown trout	Female	43.2	1.072	0.03
3-CH-2	"	"	Female	31.7	0.447	nd
2CohR1	Cohocton River (11)	Brown trout	Male	27.6	0.256	0.20
2CohR2	"	"	Female	26.7	0.251	0.13
2CohR3	"	"	Male	25.4	0.194	0.11
6R6493	Eighth Lake (12)	Rainbow trout	..	..	..	0.05
2-LAER-6	Lake Erie (13)	Burbot	..	58.4	1.980	0.19
2-LE-Hg-7	"	Coho salmon	Female	41.3	0.665	0.08
2-LE-Hg-6	"	"	Female	44.5	0.764	0.06
LE-CS 1-9-4-69	"	"	Male	56.2	2.110	0.08
2-LE-Hg-8	"	"	Male	48.3	1.147	0.06
LE-CS-6	" (Sunset Bay)	"	Male §	35.0	0.493	0.12
LE-CS-7	" "	"	Female	56.8	2.520	0.13
LE-CS-9	" "	"	Female	57.5	2.671	0.08
LE-CS-8	" "	"	Female	55.0	2.392	0.07
2-LE-3	"	Freshwater drum	..	..	..	0.04
LE-FWD-1	"	"	Male	45.0	1.005	0.07
2-LE-Hg-3	"	"	Female	40.0	0.733	0.08
2-LE-Hg-42	"	"	Female	36.8	0.670	0.04
2-LE-Hg-37	"	"	Male	36.2	0.650	0.15
2-LE-Hg-47	"	"	Female	48.3	1.385	0.18

Table 3. (*continued*)

Tag number	Water *	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
2-LE-Hg-38	"	"	Male	37.5	0.715	0.19
2-LE-Hg-45	"	"	Male	34.3	0.570	0.04
2-LE-Hg-43	"	"	Male	35.6	0.610	0.06
2-LE-Hg-41	"	"	Female	37.5	0.750	0.12
2-LE-Hg-46	"	"	Male	36.2	0.565	0.07
2-LE-Hg-40	"	"	Female	32.4	0.415	0.06
2-LE-Hg-44	"	"	Male	36.8	0.610	0.08
2-LE-Hg-39	"	"	...	...	...	nd
2-LE-Hg-48	"	"	Male	48.9	1.395	0.07
2-LE-1	"	"	...	43.2	0.695	0.12
2-LE-3	"	"	Female	30.7	0.270	0.04
2-LE-Hg-2	"	"	Female	36.2	0.612	0.06
2-LE-2	"	"	Female	50.8	1.750	0.08
2-LE-Hg-1	"	"	Male	38.1	0.615	0.04
LE-FWD-2	"	"	Male	29.2	0.364	0.13
2-LE-4	"	Gizzard Shad	Composite of 31 fish			0.25
2-LEL-2	"	Lake trout	...	...	...	0.23
2-LE-Hg-31	"	Rock bass	Male	27.3	0.358	0.09
2-LE-Hg-51	"	Silver bass	Female	37.5	0.680	0.11
2-LE-Hg-68	"	"	Female	36.2	0.487	0.08
2-LE-Hg-71	"	Silver bass	Female	35.6	0.487	0.12
2-LE-Hg-53	"	"	Female	36.2	0.615	0.12
2-LE-Hg-70	"	"	Male	34.9	0.503	nd
2-LE-Hg-52	"	"	Female	36.2	0.625	0.10
2-LE-Hg-72	"	"	Female	40.0	0.840	0.11
2-LE-Hg-69	"	"	Male	34.9	0.425	0.21
LE-SMB-1	"	Smallmouth bass	Male	43.5	0.932	0.08
2-LE-Hg-54	"	"	Female	40.7	0.860	0.08
2-LE-Hg	"	"	...	...	...	0.25
2-LE-Hg-50	"	"	Female	34.9	0.645	0.20
2-LE-Hg-60	"	"	Female	39.4	0.649	0.06
2-LE-Hg-62	"	"	Female	45.7	1.300	0.06
2-LE-Hg-58	"	"	Male	33.0	0.360	0.08
2-LE-Hg-56	"	"	Female	35.6	0.682	0.07

TABLE 3. (*continued*)

Tag number	Water *	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
2-LE-Hg-59	"	"	Female	37.5	0.741	0.06
2-LE-Hg-57	"	"	Male	40.0	0.695	0.11
2-LAER-5	"	Sucker		50.8	1.474	0.03
2-LE-Hg-13	"	"	Female	51.5	1.530	0.03
2-LAER-4	"	"	Male	30.5	0.334	0.13
2-LE-Hg-12	"	"	Female	48.9	1.296	0.04
2-LE-Hg-65	"	"	Female	44.5	1.150	0.03
2-LE-Hg-63	"	"	Male	46.4	1.190	0.06
2-LAER-3	"	"	Male	48.3	1.097	0.09
2-LE-Hg-11	"	"	Male	45.7	1.040	0.04
2-LE-Hg-64	"	"	Female	46.4	1.260	0.05
2-LE-Hg-67	"	"	Female	43.2	1.120	0.03
2-LE-Hg-66	"	"	Female	49.5	1.150	0.03
2-LE-Hg-23	"	Walleye pike	Female	69.3	4.210	0.08
2-LE-Hg-25	"	"	Female	64.7	2.920	0.06
2-LE-Hg-32	"	"	Female	63.5	3.375	0.09
2-LE-Hg-4	"	"	Female	63.5	2.310	0.04
2-LE-Hg-33	"	"	Male	73.7	5.070	0.18
2-LE-Hg-35	"	"	Female	67.4	3.800	nd
2-LE-Hg-36	"	"	Female	62.3	3.380	nd
2-LE-Hg-21	"	"	Female	68.5	4.219	0.09
2-LE-Hg-16	"	Yellow perch	Female	31.7	0.515	nd
2-LE-Hg-29	"	"	Female	33.0	0.609	nd
2-LE-Hg-30	"	"	Female	27.9	0.485	0.04
2-LE-Hg-17	"	"	Female	31.1	0.516	0.04
2-LE-Hg-28	"	"	Female	34.3	0.697	0.06
2-LE-Hg-26	"	"	Female	32.4	0.612	0.06
2-LE-Hg-20	"	"	Female	33.3	0.605	0.08
2-LE-Hg-19	"	"	Female	36.2	0.735	0.06
2-LE-Hg-18	"	"	Female	34.9	0.694	0.03
2-LE-Hg-27	"	"	Female	30.5	0.450	nd
5-FLK-3	Fern Lake (14)	Rock bass	Male	26.2	0.426	0.03

Table 3. *(continued)*

Tag number	Water *	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
6R6641	Forked Lake (15)	Brook trout	..	43.7	0.945	0.05
6R6642	"	Lake trout	Male	53.3	0.854	0.04
6R6648	"	Smallmouth bass	Female	37.1	0.950	nd
6R6640	"	Speckled trout	Female	35.6	0.645	0.09
4-4L-12	Fourth Lake (16)	Lake trout	Female	55.9	1.872	nd
4-4L-10	"	"	Male	37.8	0.497	0.03
4-4L-11	"	"	..	..	..	0.04
4-4L-23	"	Sucker	Male	29.2	0.301	0.05
4-4L-24	"	"	Male	35.6	0.554	0.03
4-4L-22	"	"	Female	30.2	0.336	0.03
J-6267	Genesee River (17)	Smallmouth bass	..	..	..	0.08
J6204	Hemlock Lake (18)	Bullhead-catfish	..	28.4	0.279	0.06
J6203	"	"	Male	36.1	0.739	0.04
J6202	"	"	..	28.2	0.341	0.06
J6198	"	Chain pickerel	..	31.7	0.229	0.03
J6199	"	"	Male	45.7	0.754	0.08
J6197	"	"	..	50.8	1.245	0.04
J6299	"	Lake trout	Male	67.5	3.987	0.22
J6298	"	"	Female	77.8	4.270	0.17
J6300	"	"	Male	75.5	4.580	0.15
J6229	"	Largemouth bass	Male	26.2	0.344	0.04
J6201	"	"	..	28.4	0.468	0.11
J6200	"	Rainbow trout	Male	38.1	0.688	0.03
J2067	Hudson River (19)	Atlantic sturgeon	Imm	46.0	0.410	0.13
J2065	"	"	Female §	62.0	1.285	0.20
J2064	"	"	Male	98.0	5.076	0.19
J2066	"	"	Male §	64.0	1.075	0.10
J2068	"	"	Imm	64.5	1.348	0.08
6R6667	"	Goldfish	..	..	..	0.04
6R6666	"	"	..	..	..	0.06

Tag number	Water *	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
6R6665	"	"	. .	. .	. .	nd
J2076	"	Shortnose sturgeon	Imm	47.3	0.636	0.40
J2070	"	Striped bass	Male	57.6	2.256	0.40
J2071	"	"	Male	53.4	2.042	0.67
J2072	"	"	Female	41.1	0.780	0.36
J2069	"	"	Male	54.4	2.072	0.53
8HUDR2	"	"	Male	40.6	0.800	0.23
8HUDR1	"	"	Male	40.2	0.850	0.32
6R6554	Indian Lake (20)	Northern pike	Male	73.0	2.735	nd
6R6142	"	"	Male	64.3	1.433	nd
6R6553	"	Walleye pike	Male	70.6	2.562	nd
6R6144	"	"	Male	29.7	0.380	0.03
6R6139	"	Whitefish	Female	38.6	0.595	0.12
6R6140	"	"	Male	43.2	0.789	nd
6R6141	"	"	Male	45.3	0.641	0.10
6R6143	"	"	Male	46.0	0.873	0.03
5-LCCC-1	Lake Champlain (21)	Channel catfish	Male	53.4	1.630	0.04
5-LCCC-2	"	"	Female	76.1	6.200	0.04
5-LCCC-3	"	"	. .	61.0	2.630	0.03
6R6592	"	"	Female	52.0	1.700	0.03
6R6591	" (South Bay)	"	Male	47.8	1.130	nd
6R6593	" "	Freshwater drum	Male	60.5	2.760	0.04
6R6588	" "	"	Female	31.7	0.306	nd
6R6590	" "	"	Female	48.8	1.165	0.18
6R6589	" "	Walleye pike	Male	36.8	0.423	0.03
6R6587	" "	"	Male	64.8	3.070	nd
6R6585	" "	"	Female	40.2	0.566	0.04
6R6586	" "	"	Male	54.9	1.455	0.03
6R6676	Lake George (22)	Black crappie	Female	20.3	0.109	0.03
6R6675	"	"	Female	31.2	0.584	0.08
6R6452	"	"	Female	28.7	0.352	nd

Table 3. (*continued*)

Tag number	Water •	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
6R6680	"	Brown bullhead	Female	32.8	0.686	nd
6R6642	"	"	Male	33.3	0.418	nd
6R6454	"	"	Female	32.8	0.508	0.09
6R6679	"	Bullhead-catfish	Female	30.0	0.469	nd
6R6450	"	Chain pickerel	Male	35.6	0.258	nd
6R6672	"	Lake trout	Female	71.0	3.570	0.08
6R573	"	"	..	..	..	nd
6R6674	"	"	Male	68.8	3.125	0.07
6R6673	"	"	Female	70.1	3.241	0.05
6R6441	"	Largemouth bass	Male	41.1	0.973	0.05
6R6453	"	"	Female	36.3	0.743	0.04
6R6440	"	"	Male	40.4	0.789	0.09
6R6677	"	Northern pike	Female	64.0	1.820	0.03
6R6671	"	"	Female	59.5	1.780	nd
6R6404	"	Northern pike	Female	75.0	3.180	0.09
6R6407	"	"	Female	64.7	2.950	0.06
6R6406	"	"	Male	60.5	3.000	nd
6R6678	"	Rainbow trout	Female	50.0	2.415	nd
6R6681	"	"	Male	55.3	2.440	nd
6R6682	"	"	Male	50.8	1.690	0.05
6R639	"	"	Female	41.9	0.692	0.09
6R6425	"	"	Female	58.6	2.41	0.03
6R6449	"	Smallmouth bass	Female	42.4	1.235	0.04
6R6433	"	White sucker	Female	53.0	1.139	nd
6R6434	"	"	Male	46.3	0.872	0.12
6R6432	"	"	Male	47.3	0.906	0.06
2-LO-4	Lake Ontario (23)	Black crappie	..	..	..	0.09
J-6067	"	Carp	..	27.4	0.419	0.12
73-17-69	" (Pennicon Reef)	Coho salmon	Male	64.8	3.780	0.37
73-51-69	" (Wellington Beach)	"	Male	60.5	2.120	0.25
73-29-69	" (False Duck Is.)	"	Female	55.8	2.040	0.23
73-49-69	" (Outlet Beach)	"	Female	63.0	3.110	0.08
73-18-69	" (Amherst Bar)	"	Male	60.1	3.190	0.21

TABLE 5. (*continued*)

Tag number	Water *	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
73-27-69	" (Pt. Petre)	"	Female	56.1	2.090	0.47
73-52-69	" (Wellington Beach)	"	Female	66.0	3.290	0.17
73-48-69	" "	"	Female	64.8	3.010	0.09
22-LO-4	"	"	Male	50.0	1.400	0.25
73-30-69	"	"	Female	51.3	2.060	0.27
73-50-69	" (Wellington Beach)	"	Male	54.0	1.620	0.35
73-23-69	" (Perch Cove)	"	Male	60.4	2.090	0.19
73-47-69	" (Shelter Valley Mouth)	"	Female	64.0	2.890	0.21
73-44-69	" (Wellington Beach)	"	Male	64.8	3.010	0.23
73-53-69	" (Wellington Beach)	"	Male	59.9	2.100	0.21
69-LO-CS1	"	"	Female	57.7	2.555	0.09
73-16-69 (eggs)	" (Pennicon Reef)	"	..	..	..	0.09
73-16-69	" "	"	Female	56.8	2.460	0.25
73-13-69	" "	"	Male	50.3	1.740	0.28
23-LO-4	"	"	Female	55.9	2.180	0.20
21-LO-4	"	"	Female	48.3	0.965	0.20
20-LO-4	"	"	Male	58.5	2.640	0.25
J-6038	"	Rock bass	Female	22.8	0.268	0.15
J-6097	"	"	Female	24.1	0.288	0.07
J-6098	"	"	Male	25.5	0.436	0.08
J-6085	"	"	Female	22.8	0.301	0.18
4CI-2	" (Carleton Is.)	Smallmouth bass	Male	27.4	0.258	0.19
4CI-1	" "	"	Male	28.9	0.320	0.16
4CI-3	" "	"	Male	34.0	0.573	0.35
4RA2637	" (Pt. Peninsula)	"	Female	37.4	0.855	0.30
4RA2635	" "	"	Female	33.0	0.558	0.22
4RA2632	" "	"	..	..	..	0.42
4RA2638	" "	"	Female	33.6	0.644	0.41
4RA2646	" "	"	Female	30.5	0.533	0.20
4RA2644	" "	"	Male	38.1	0.892	0.51
4RA2650	" "	"	Male	27.9	0.320	0.09
9-LO-4	"	"	Female	37.6	0.826	0.37
16-LO-4	"	"	Male	40.7	1.014	0.50
17-LO-4	"	Splake	Imm	34.8	.523	0.04

TABLE 3. (*continued*)

Tag number	Water *	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
15-LO-4	"	Sucker	Male	39.1	0.657	0.03
14-LO-4	"	"	Female	39.1	0.703	0.08
J-6030	"	White bass	..	24.9	0.207	0.28
J-6038	"	"	..	..	..	0.15
J-6027	"	"	Female	25.5	0.272	0.18
LP-NE-2	Lake Placid (24)	Brook trout	Female	30.5	0.360	0.03
5-NELP-2	"	Lake trout	..	41.5	0.726	nd
5-NELP-1	" (North End)	"	Male	31.7	0.299	0.03
3LP-5	"	Northern pike	Male	76.6	3.870	0.03
1LP-5	"	"	Male	57.4	1.408	0.04
2LP-5	"	"	Male	64.0	1.642	0.04
5-LKP-1	"	Rainbow trout	Female	25.4	0.225	0.05
5-LKP-3	"	"	Female	40.9	0.715	nd
5-LKP-2	"	"	Female	42.1	0.779	nd
5-LKP-4	"	Smallmouth bass	Male	29.2	0.336	0.03
5-LKP-5	"	"	Female	46.3	1.420	nd
5-LP-WS-1	"	White sucker	..	43.7	1.440	0.04
5-LP-WS-3	"	"	..	30.5	0.417	0.04
5-LP-WS-2	"	Yellow perch	Male	23.6	0.173	0.04
5-LP-5	"		Female	31.7	0.435	nd
6R6118	Lake Pleasant (25)	Brown bullhead	Male	34.3	0.681	nd
6R6119	"	"	Female	34.8	0.673	nd
6R6120	"	Bullhead-catfish	Male	25.5	0.309	nd
6R6126	"	Chain pickerel	Female	35.0	0.255	nd
6R6127	"	"	Female	38.4	0.392	nd
6R6128	"	"	Female	39.2	0.405	0.07
6R6131	"	Largemouth bass	Female	35.0	0.622	0.03
6R6129	"	Rainbow trout	Female	42.7	1.068	nd
6R6124	"	Rock bass	Female	26.4	0.461	nd
6R6123	"	"	Female	25.4	0.325	nd
6R6125	"	Smallmouth bass	..	..	..	0.03
6R6132	"	"	Female	32.7	0.484	0.12

TABLE 3. *(continued)*

Tag number	Water *	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
6R6130	"	"	Female	49.3	1.775	0.08
6R6117	"	Whitefish	Male	53.8	2.153	0.04
6R6135	"	Yellow perch	Male	30.0	0.438	nd
6R6133	"	"	Male	27.4	0.335	nd
5-1gp-8	Little Green Pond (26)	Rainbow trout	Female	34.1	0.392	nd
5-1gp-7	"	"	Male	32.0	0.370	nd
5-1gp-9	"	"	Female	38.6	0.608	nd
5-1gp-1	"	Whitefish	Female	53.4	1.805	0.04
5-1gp-2	"	"	Female	57.1	2.041	nd
5-1gp-3	"	"	Male	50.8	2.050	nd
LY-3-1	Little York Lake (27)	Brown trout	Male	34.3	0.456	nd
LY-3-3	"	Bullhead-catfish	Female	31.7	0.414	0.07
LY-3-2	"	Largemouth bass	Male	33.2	0.720	nd
6R6546	Long Lake (28)	Largemouth bass	Female	43.2	1.128	nd
6R6541	"	Northern pike	Female	53.8	1.167	nd
6R6540	"	"	Male	71.4	2.305	nd
6R6542	"	"	Male	61.0	1.335	nd
6R6545	"	Smallmouth bass	Female	40.9	0.767	0.03
6R6544	"	"	Female	35.6	0.672	0.03
6R6414	Loon Lake (29)	Smallmouth bass	..	..	0.201 ‡	0.06
6R6409	"	Walleye pike	Female	..	0.190 ‡‡	0.03
6R6410	"	"	Female	..	0.187 ‡‡‡	0.05
6R6408	"	"	Female	..	0.232 ‡‡	0.06
3-OneL-1	Oneida Lake (30)	Walleye pike	Female	59.6	2.060	0.07
3-OneL-2	"	"	Female	48.3	1.030	0.05
OS-P154-4-1	Onondaga Creek (31)	Brown trout	Female	32.2	0.386	nd
OS-P154-4-3	"	"	..	24.1	0.181	0.03
OS-P154-4-2	"	"	..	29.5	0.314	0.08

Table 3. (*continued*)

Tag number	Water *	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
7-OTSL-1	Otsego Lake (32)	Cisco	..	25.9	0.161	0.04
7-OTSL-2	"	"	Male	34.3	0.365	0.25
7-OTSL-3	"	"	Female	36.1	0.488	0.12
7-OTSL-6	"	Lake trout	..	..	..	0.06
7-OTSL-5	"	"	..	..	..	0.03
7-OTSL-4	"	"	..	..	..	0.06
7-OTSL-9	"	Whitefish	..	..	..	0.06
7-OTSL-7	"	"	..	..	..	0.08
7-OTSL-8	"	"	..	..	..	0.06
3 PR-7	Pepacton Reservoir (33)	Brown trout	Female	51.5	1.880	0.13
6R6105	Piseco Lake (34)	Brown bullhead	Male	31.7	0.425	0.03
6R6104	"	Smallmouth bass	Female	35.3	0.571	0.04
6R6103	"	Whitefish	Female	38.1	0.431	0.03
6R6102	"	"	Female	31.7	0.295	0.05
6R6101	"	"	Male	34.8	0.328	0.07
6R6111	"	Yellow perch	Male	29.2	0.262	0.06
6R6523	Raquette Lake (35)	Lake trout	..	..	..	0.12
6R6207	"	Smallmouth bass	Female	28.9	0.287	0.07
6R6206	"	"	Female	27.6	0.287	0.08
6R6208	"	"	Female	27.4	0.251	0.12
6R6245	"	Whitefish	Imm	33.0	0.337	0.04
6R6244	"	"	Female	34.8	0.453	0.03
6R6625	"	"	Female	31.7	0.349	0.11
6R6243	"	"	Female	35.6	0.497	nd
6R6627	"	"	Male	34.0	0.388	nd
6R6626	"	"	Male	35.3	0.439	nd
2RL-1	Rushford Lake (36)	Lake trout	Female	75.2	4.195	0.30
5SL-5	Saranac Lake (37)	Smallmouth bass	Female	33.2	0.684	nd

TABLE 3. (*continued*)

Tag number	Water *	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
69-SR-CS-6	Salmon River (38)	Coho salmon	Male	61.5	1.910	0.49
69-SR-CS-4	"	"	Female	56.8	1.983	0.19
69-SR-CS-2	" (Pulaski, N.Y.)	"	Female	63.0	2.072	0.32
69-SR-CS-10	"	"	Male	61.8	1.920	0.31
69-SR-CS-7	"	"	Male	60.5	2.046	0.40
69-SR-CS-8	"	"	Male	57.3	1.984	0.07
SR-CS-1	"	"	Female	48.8	1.036	0.27
69-SR-CS-5	"	"	Female	53.9	1.661	0.43
69-SR-CS-11	"	"	Female	61.8	1.840	0.33
CSJ-SR-2	"	"	Male	35.6	0.620	0.18
CSJ-SR-1	"	"	Male	40.7	0.663	0.24
CSJ-SR-3	"	"	Male	38.1	0.544	0.10
69-SR-CS-9	"	"	Female	61.8	1.735	0.32
SRCSJ-70-1	"	"	Imm	33.0	0.444	0.30
SRCSJ-70-2	"	"	Imm	30.5	0.280	0.11
SRCSJ-70-3	"	"	Imm	34.9	0.520	0.12
SRCSJ-70-4	"	"	Imm	32.4	0.400	0.10
SRCSJ-70-5	"	"	Imm	30.9	0.326	0.12
SRCSJ-70-6	"	"	Imm	30.9	0.327	0.20
6R6403	Saratoga Lake (39)	Walleye pike	Female	..	0.357	0.04
1	Schroon Lake (40)	Lake trout	..	..	..	0.03
3-SKL-1	Skaneateles Lake (41)	Rainbow trout	Female	50.8	1.235	nd
3-SKL-3	"	"	Female	38.1	0.644	nd
5M381	Spring Brook (42)	Coho salmon	Male	54.4	1.710	0.21
4RA2991	"	"	..	56.8	2.160	0.21
4RA3601	"	"	..	61.5	2.680	0.21
9SL-5	St. Lawrence River (43)	Brown bullhead	..	..	..	0.04
101SL-4	"	Muskalonge	Male	77.5	3.832	0.20
1STL-4	"	Smallmouth bass	Male	29.5	0.398	0.25

TABLE 3. (*continued*)

Tag number	Water *	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
6STL-4	"	"	Male	26.8	0.263	0.21
2STL-4	"	"	Male	26.9	0.280	0.24
6SL-5	"	"	..	..	..	nd
4STL-4	"	"	Female	30.0	0.339	0.31
3STL-4	"	"	Imm	23.9	0.242	0.25
5STL-4	"	"	Male	29.5	0.344	0.24
G429	"	Sturgeon	..	102.5	6.830	0.44
G435	"	"	..	89.6	4.540	0.34
G430	"	"	..	..	3.630	0.33
G432	"	"	..	97.3	5.69	0.20
G434	"	"	..	100.8	6.590	0.36
G431	"	"	..	103.5	8.200	0.31
G433	"	"	..	96.3	5.910	0.40
2-SL-56	" (Massena)	"	..	..	..	0.16
1-SL-54	"	"	..	..	..	0.40
4-SLS-6	" (Massena)	"	Male	95.5	7.210	0.31
3-SL-56	"	"	..	..	..	0.21
4-MAS-1	" (Massena)	Walleye pike	..	..	..	0.06
1-STLHg-4	"	"	..	..	..	0.30
4-MAS-2	" (Massena)	"	Female	45.3	1.060	0.15
4-MAS-3	"	"	Female	65.5	3.527	0.16
3-SQR-1	Susquehanna River (44)	Walleye pike	..	..	..	0.03
3-Susq.R.-6	"	"	Male	22.8	0.125	0.15
3-Susq.R.-7	"	"	Male	33.0	0.305	0.15
3-Susq.R.-5	"	Yellow perch	Male	27.9	0.268	0.04
3-Susq.R.-4	"	"	Male	24.8	0.166	0.08
6R6456	Trout Lake (West Shore) (45)	Chain pickerel	Female	62.0	1.570	0.04
6R6457	" "	"	Male	46.3	0.785	nd
6R6458	"	"	Female	49.5	0.918	0.03
6R6459	"	Smallmouth bass	Female	43.7	1.197	nd
5-US-2	Upper Saranac Lake (46)	Largemouth bass	Female	34.8	0.904	0.03

TABLE 3. (*continued*)

Tag number	Water *	Species	Sex	Length (centimeters)	Weight (kilograms)	Residue (ppm) †
5-US-1	"	"	Female	31.2	0.432	0.03
6R6504	Utowana Lake (47)	Smallmouth bass	Female	42.9	0.949	0.03
6R6505	"	"	Male	42.5	1.030	0.03
6R6506	"	Rainbow trout	Male	43.0	0.844	nd
6R6508	"	"	Female	41.5	0.775	nd
1-ML-2	Waneta Lake (48)	Muskalonge	. .	. .		0.08
6R569	West Canada Lake (49)	Lake trout	Male	53.3	1.268	0.03
6R568	"	"	Female	38.6	0.426	nd

* Numeral in parentheses indicates location of water as shown in Figure 1.
§ Immature fish of known sex; immature fish of unknown sex indicated as "Imm".
† "nd" means non-detectable.
‡ One fillet.

Table 4. Total Arsenic Found in Lake Trout from Cayuga Lake in Relation to Age of the Fish

Age (years)	Arsenic (ppm)
2	0.13
3	0.15
4	0.17
5	0.25
6	0.21
7	0.21
8	0.22
9	0.21
10	0.21
11	0.17

analytical survey of arsenic in fish from New York State waters, advantage was taken of the availability of 460 fish which were sampled in 1969 from 49 waters throughout the State.

The fish were captured by netting, and their species, sex, length and weight were recorded. All fish were decapitated and eviscerated. The remainder was ground in a food chopper, thoroughly mixed and frozen in polyethylene bags prior to analysis. Arsenic was determined by dry ashing 15 grams of fish overnight with magnesium nitrate at 600° C. using the procedure of Evans and Bandemer (1954) and arsine distillation and colorimetric analysis using silver diethyldithiocarbamate (Fisher Scientific Co., 1960). The recoveries of arsenic added to fish as sodium arsenite prior to ashing are given in Table 1. The method was judged to be sensitive to about 0.03 ppm of arsenic in fish.

Table 2 lists, alphabetically by common name, the various species of fish collected in the survey. The results of analysis of the fish for arsenic are given in Table 3. The residues of arsenic shown are in parts per million on a fresh-weight basis and are not corrected for percentage of recovery. The fish species, location of netting, sex, length and weight are included insofar as recording was complete. Figure 1 shows the approximate location of the various waters indicated by number in Table 3.

Upon examination of the data, some general observations can be made. Fish from Lake Ontario, Canandaigua Lake and the Hudson, St. Lawrence and Salmon Rivers were comparatively high in arsenic content. Those from certain other waters, such as Spring Brook, may also have been high, but the number of samples taken was inadequate. In general, fish from Lake Erie, which is considered very polluted with many chemicals, were low in arsenic. Larger fish were generally found to contain a higher concentration. Therefore, fish from certain waters, such as the Hudson and St. Lawrence Rivers in which a preponderance of larger fish were sampled, ranked relatively high in arsenic. From the

samples collected and analyzed, possible sex-linked variations in arsenic content could not be determined.

Table 4 shows the analysis of total arsenic in a series of lake trout from Cayuga Lake that ranged in age from 2 to 11 years. The age was accurately known since fish of this species are annually stocked as fingerlings and marked regarding the date of stocking. From these limited data, arsenic does not appear to be cumulative in lake trout. In conclusion, the levels of arsenic found were well below the present tolerance of 7 ppm of combined lead arsenate on food crops and, therefore, would not appear, in themselves, to constitute a health hazard.

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MANDIBULAR AND DENTAL ANOMALIES OF WHITE-TAILED DEER [1]

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ABSTRACT

Anomalies noted in a collection of abnormal deer jaws from the Northeast are described. For a random sample of 422 specimens from New York, 11 (2.6 per cent) exhibited mandibular or dental anomalies. Seven (1.7 per cent) had developmental anomalies. Anomalies caused by injury and/or infection numbered four or 0.95 per cent of the total examined. Because this sample was not selective, these percentages are considered representative of the frequency of such anomalies among wild deer in this State.

Mandibular and dental anomalies have long been of interest to biologists. But most accounts of abnormal jaws and teeth in deer have been merely brief notations, each dealing with only one anomaly. However, there are a few notable exceptions. Rees (1969) analyzed a wide spectrum of mandibular variations; Cowan (1946) discussed 11 jaw abnormalities and diseases; Robinette (1958) described eight unusual jaw conditions; Lueth (1969) mentioned four mandibular and dental anomalies; Ryel (1963) listed two jaw malformations; and Mech et al. (1970) reported on abnormalities in the mandibular dentition of 36 white-tailed deer. Two authors, Cowan (1946) and Karstad (1967) discussed jaw abnormalities of deer caused by injury or infection, as well as genetic or developmental malformations. Neiland (1970) discussed cases of "lumpy jaw" in the Dall sheep.

Most previous articles are lacking in data on the frequency of occurrence of anomalies in deer jaws. Only six papers, Nordquist (1941), Cowan (1946), Van Gelder and Hoffmeister (1953), Southwich (1954), Rees (1969) and Mech et al. (1970) offered any statistics to indicate the frequency of anomalies and, of these, only Cowan, Rees and Mech et al. dealt statistically with anything other than maxillary canine teeth.

The present study was made as inclusive as possible, the objective

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[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-89-R. John R. Palmateer examined deer heads brought to the Wildlife Research Laboratory, from January 1969 to March 1970, for the presence of canine teeth and also recorded other anomalies. C. W. Severinghaus reviewed the manuscript and his comments are greatly appreciated.

being to collect and describe, with photographic illustrations, the many anomalous conditions affecting the jaws of white-tailed deer (*Odocoileus virginianus*) in New York and several nearby areas. The anomalies included are both those of genetic origin and those caused by injury or disease. An investigation was also undertaken to determine the frequency of occurrence of these anomalies in wild deer. The incidence of mixillary canine teeth is not included because it has been reported by Bergstrom et al. (1971).

METHODS

Two groups of deer jaws were examined. The first comprised 45 specimens exhibiting anomalies that had been collected during previous years and stored at the Wildlife Research Laboratory at Delmar, New York. This group included jaws from New York State, Anticosti Island (Quebec), Griffith Island (Ontario) and Massachusetts. A description was prepared and a photograph taken of each anomaly. Ten of the jaws were X-rayed. This was done in some cases to determine if jaws that had teeth which failed to erupt had any remnant of these teeth in the dentary bones, and in some cases to determine if injuries noted were the result of lead shot which had lodged in the mandible. Scrapings from one of several mandibles having an abnormal lumpy, honeycombed growth on the bone were cultured to determine the cause (Stone, 1970). The terminology for recording premolars follows Riney (1951) in which P_1 is considered to have been lost during evolution. The three normally occurring premolars are therefore designated as P_2, P_3 and P_4. Age of deer was determined according to Severinghaus (1949).

The second group comprised 422 jaws received at the Laboratory from January 1969 to March 1970. Each was examined for the presence of anomalies and all that showed such a condition were cleaned and saved. These specimens were collected chiefly from road kills, dog kills, starvation kills and deer taken during a special hunt in Suffolk County in 1969, while a few were contributed by a taxidermist, all within New York. Therefore, in addition to providing information on the nature of anomalies that occur in deer, they were considered to represent a random sample with respect to frequency of occurrence.

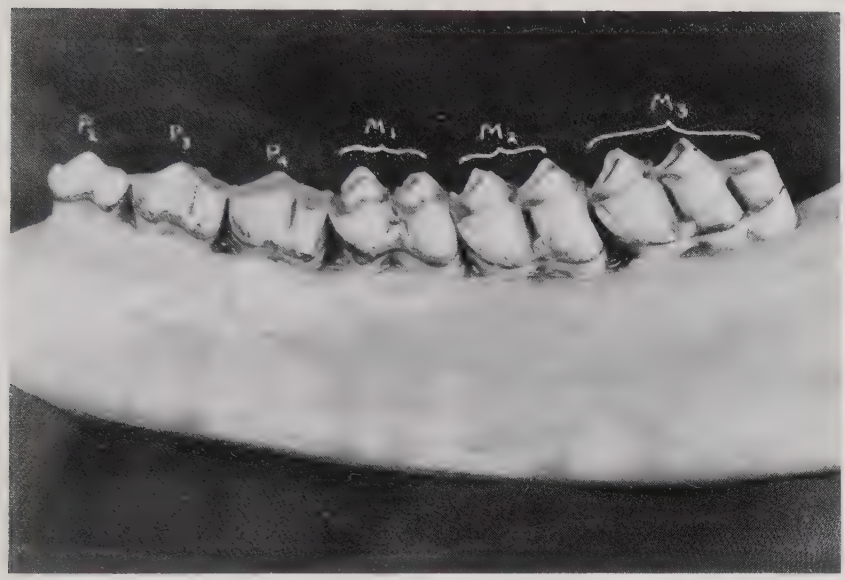
FINDINGS

The first group of jaws provided examples of all the anomalies encountered. Of the ten jaws X-rayed, none that had teeth missing [2] showed any tooth remnants in the dentary bone to indicate that the teeth ever existed. Positive evidence of bullet fragments was found in

[2] "Missing" is used in this paper to mean that there was no external evidence of the tooth having been present.

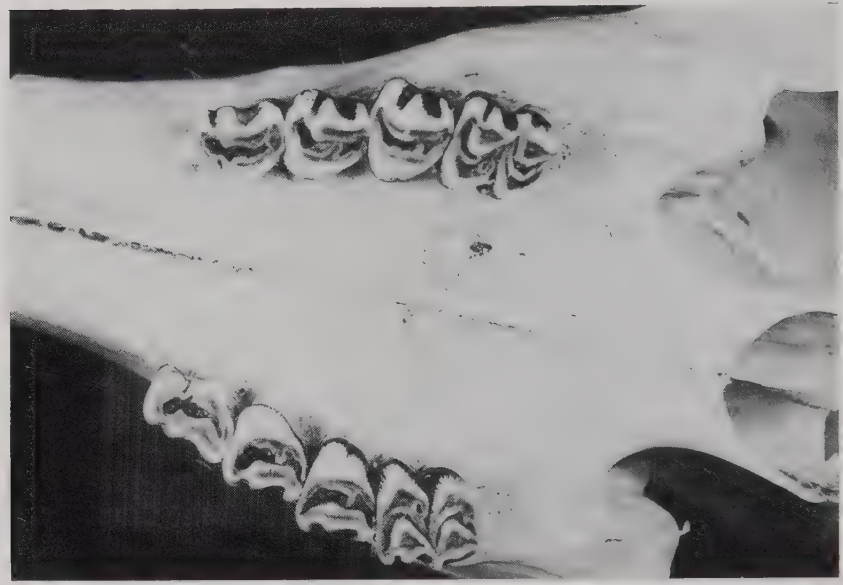
only one of the jaws X-rayed. Developmental anomalies identified consisted of the following (all conditions were unilateral unless otherwise stated).

1. Missing P_2. In three deer (ages 2½, 3½ and 7½ years) the P_2 teeth had never erupted. All were from the Adirondacks. In each case, X-rays showed no vestiges of these teeth in the dentary bone. On the oldest specimen, the roots of P_3 were partially exposed, but the cause of this is unknown.
2. Missing M_1. One 2½-year-old deer from southwestern New York had a missing M_1 on both dentary bones. There was no gap left between P_4 and M_2, indicating that the eruption failure was not the result of injury.
3. Missing M_2 and M_3. One 4½-year-old deer from the Adirondacks had both M_2 and M_3 missing on both sides of the maxilla, neither tooth having ever erupted. As a consequence, the opposing mandibular molars exhibited no wear. X-rays revealed no trace of the missing teeth.
4. Missing M_3. In two deer from the Adirondacks (ages 1 year 7 months and 3½ years) the M_3 teeth had never erupted. X-rays indicated no vestiges of these teeth in the dentary bones. On the younger deer, the roots of M_2 were exposed and the dentary bone was slightly swollen and somewhat porous in that area. These lesions were similar to those of *Actinomyces bovis* infestations, i.e., "lumpy jaw", which may have been the cause of the root exposure.
5. Extra incisors. A 3½-year-old deer from the Adirondacks had an extra incisor on each dentary bone. The supernumerary teeth developed just posterior to the normal I_1 teeth and resembled them. The other incisiform teeth appeared normal.
6. Extra premolars. Five deer had extra premolars. In four (ages 1 year 7 months and 2½, 5½ and 7½ years) the extra premolar had developed between P_2 and P_3 and resembled P_3. The first two of these were from the Adirondacks, and the other two were from Anticosti Island (Quebec) and southwestern New York, respectively. In the yearling, the condition was bilateral, one extra tooth erupting on the buccal side of the right dentary bone and one on the lingual side of the left dentary bone. In the 5½-year-old animal, P_2 on the opposite dentary bone was missing and X-rays indicated no trace of it. On the fifth specimen, a 1-year-7-month-old deer from Warren County (New York), the supernumerary premolar occurred on the left dentary bone between P_3 and P_4 and resembled P_4.
7. Extra molar. One 2½-year-old deer from the Adirondacks, de-



Buccal view of left dentary bone of adult white-tailed deer showing normal complement of the molariform teeth, i.e., three premolars and three molars.

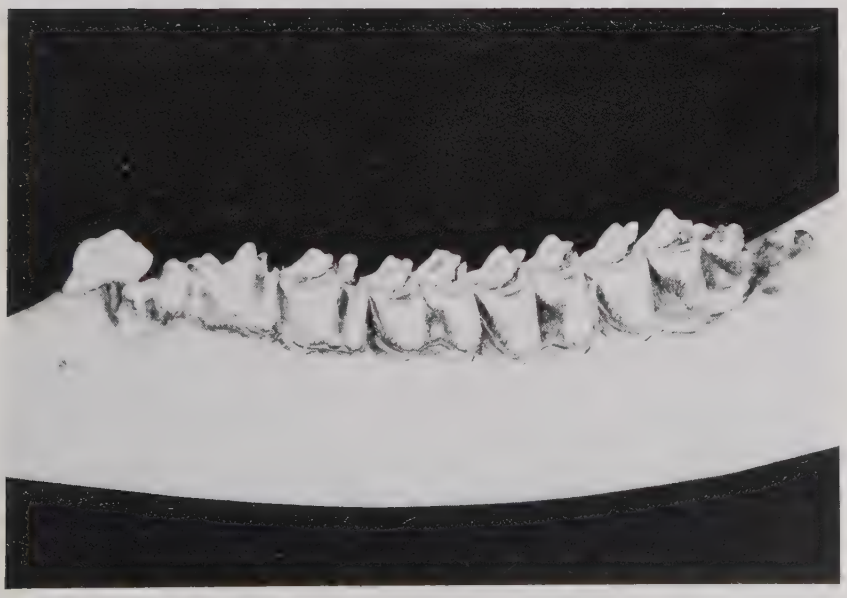
Buccal view of left dentary bone of 2½-year-old deer with P_2 missing, never having erupted.



Maxilla of 4½-year-old deer with both M_2 and M_3 missing on both sides, never having erupted.

Buccal view of right dentary bone of 3½-year-old deer with M_3 missing, never having erupted.

Incisiform teeth of 3½-year-old deer showing, in addition to full complement of normal teeth, two extra incisors just posterior to and resembling I_1 teeth.



Buccal view of left dentary bone of 2½-year-old deer showing extra premolar, similar to P_3, between and to one side of P_2 and P_3 which are slightly displaced.

Lingual view of left dentary bone of 4½-year-old deer showing extra cusp between M_2 and M_3 that caused all the molars to be somewhat twisted.

Buccal view of left dentary bone 3½-year-old deer showing extra cusp on M_3 posterior to the normal cusps.

Buccal view of left dentary bone of 4½-year-old deer with M_2 erupted perpendicular to its normal orientation causing M_1 and M_3 to be slightly twisted and displaced. The sidewise eruption also caused an outgrowth of bony tissue beneath it.

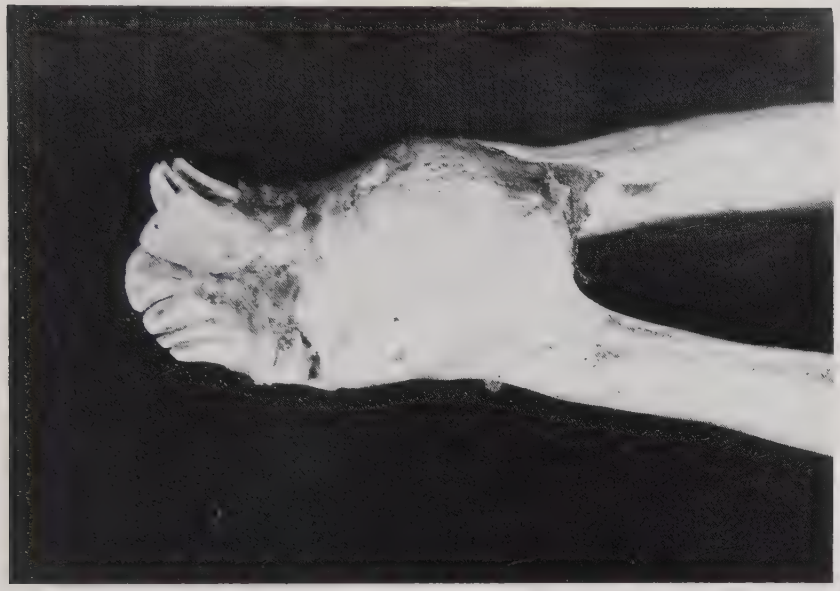
Buccal view of left dentary bone of 1-year-7-month-old deer with M_1 missing and replaced by tooth resembling P_4.

veloped an extra molar just posterior to and resembling M_3. This condition was bilateral.

8. Extra cusp between premolars. An extra cusp developed between P_3 and P_4 on the right dentary bone of the 1-year-7-month-old deer from Warren County noted under Item 6.
9. Extra cusp on M_3. Three deer from the Adirondacks developed an extra cusp on M_3. On one, age 4½ years, the extra cusp erupted between M_2 and M_3 on the lingual side. On the other two, ages 2½ years and 3½ years, the extra cusp was posterior to the normal cusps.
10. Abnormal M_2. On two deer, ages 1 year 6 months and 4½ years, M_2 erupted perpendicular to the normal orientation of the tooth row. On the younger animal, taken in western New York, P_2 was erupting under p_2 before the deciduous tooth was shed, and an impaction had destroyed the portion of M_1 just anterior to the sideways M_2. The older deer was taken in the Adirondacks.
11. Two P_4 teeth. On both dentary bones of a 1-year-7-month-old deer from the Adirondacks, the M_1 tooth was missing. In its place was a tooth resembling P_4 that appeared to have erupted prior to M_2. Just anterior to this unusual tooth was another normal appearing P_4 in proper erupting sequence.
12. Abnormal spur on last cusp of M_3. On one 6½-year-old deer from the Adirondacks, a short spur from the last cusp of M_3 projected posteriorly and down, joining with the dentary bone.
13. Hollow posterior to M_3. The dorsal portion of the dentary bone just posterior to the M_3 tooth was largely hollowed out on the mandible of one 3½-year-old deer from the Adirondacks. There was no evidence of previous injury or bone damage which might have caused the hollowing out, and the other dentary bone of the mandible was normal in appearance.
14. Abnormally small jaw. The teeth of one 3½-year-old deer from central New York were all of normal size and shape for the age of the animal, but they were crowded on dentaries about the size of those of a 7-month-old fawn.

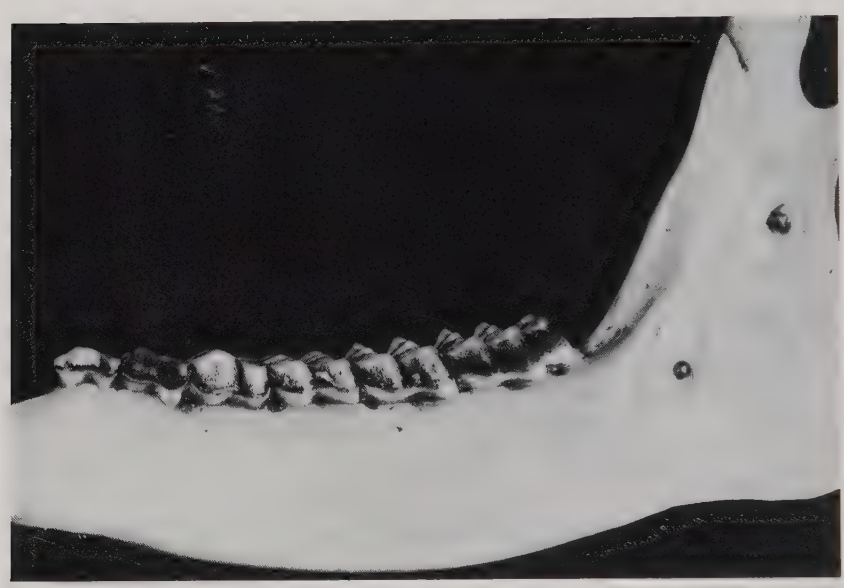
In addition to these anomalies, 23 mandibles had various malformations resulting from injury and/or infection, one jaw sometimes being affected in several different ways. The injuries and infections recorded consisted of the following:

1. Mended fractures. Eight and possibly a ninth deer, ranging in age from 6 months to 7½ years, had mended fractures of various portions of the dentary bone. Four of these animals were from



Lower jaw of 8- to 9-month-old fawn the left dentary bone of which had been fractured resulting in a large abnormal bone growth and causing one permanent incisor to be displaced and twisted perpendicular to its normal position.

Buccal view of right dentary bone of 3½-year-old deer showing partially mended fracture between M_1 and M_2 that caused distortion of the jaw and exposure of the molar roots, with accompanying abnormal tooth wear.



Buccal view of left dentary bone of 4½-year-old deer showing two birdshot pellets embedded in it.

Buccal view of right dentary bone of 4½-year-old deer with impacted twig between P_3 and P_4.

the Adirondacks; two were from the Catskills; two were from Massachusetts; and one was recorded only as from New York.

2. Bullet wounds. Six and possibly a seventh deer, ranging in age from 6 months to 5½ years, had bullet wounds. Five of these deer were from the Adirondacks; one was from the Catskills; and one was from Massachusetts.
3. Twig impactions. Five deer, ranging in age from 1 year 7 months to 4½ years, had twig impactions. Three of these were from the Adirondacks; one was from southwestern New York and one was recorded only as being from New York.
4. "Lumpy jaw" (actinomycosis). Eight jaws, ranging in age from 6 months to 5½ years, exhibited an appearance closely resembling that of "lumpy jaw" mandibles infected with colonies of *Actinomyces bovis*. The one jaw from which a culture was made was found to contain this bacterium. Five of these jaws were from the Adirondacks; one was from the Catskills; one was from the Seneca Army Depot; and one was recorded only as being from New York.

Because collection of the second group was not selective, the frequency of anomalies in this group is considered representative of that among wild deer in New York. No type of anomaly was encountered that had not been noted in the first group. Of the 422 jaws examined, 11 (2.6 per cent) exhibited anomalies. Developmental anomalies numbered seven (1.7 per cent), of which five involved jaws where one or both P_2 teeth had never erupted. This was 71.3 per cent of the developmental anomalies and 1.2 per cent of the total sample. Anomalies caused by injury and/or infection numbered four or 0.95 per cent of the total examined.

DISCUSSION

Many of the developmental anomalies recorded in this study are not known to have been reported elsewhere. These include missing molars, M_2 teeth erupting sideways, a P_4-like tooth replacing M_1, a spur on M_3 and a hollow posterior to M_3.

Also included in this category is the mandible of a 3½-year-old deer on which the teeth were normal but the dentary bone was the size of that of a 7-month-old fawn. This condition may have had the same effect on tooth wear as has brachygnathism (known as "parrot-mouth" or "Andy Gump jaw"), but this case was definitely not typical brachygnathism. On this jaw, the entire dentary bone was in miniature as opposed to the usual shortening of the mandible only in the diastema. Cases of true "parrot-mouth" in deer have been reported in many localities: in Utah, by Robinette and Aldous (1955), in Michigan by

Ryel (1963), in Ontario (Canada) by Karstad (1967), and in Alabama by Lueth (1969). Although this paper does not deal with brachygnathism in New York, Johnson (1935) reported a case of "parrot-mouth" from the Adirondacks and New York wildlife biologists have found it "fairly common."

The other developmental anomalies described have been reported elsewhere. Extra incisors have been reported in four papers. Cowan (1946) mentioned a black-tailed deer with a supernumerary incisor; Fowle and Passamore (1948) reported a deer with an extra I_3 between I_2 and I_3 on the left dentary bone; Mech et al. (1970) reported an extra permanent I_1, two deciduous first incisors located directly behind the permanent teeth, an I_1 rotated 45°, and the canine on each side situated directly posterior to the I_2 and I_3. Robinette (1958) listed a 2-week-old fawn with an extra deciduous incisor posterior to i_2 and i_3 on the right dentary bone and a 5-year-old deer with two extra I_2 teeth. Lueth (1969) reported occasional extra P_3 teeth. Extra P_4 and M_3 teeth were reported by Mech et al. (1970). Extra M_3 teeth were also reported by Verme and Ozoga (1966) and Verme (1968). Cowan (1946) also mentioned a deer with an extra cusp on M_2. Supernumerary cusps on M_3 were noted by Rees (1969). Missing M_3 teeth, as well as a third root on P_3 and an extra cusp or spike on M_3, were reported by Mech et al. (1970). Missing P_2 teeth were reported by Robinette (1968) in a 28-month-old mule deer, by Mech et al. (1970) and by Lueth (1969).

Maxillary canine teeth, with an incidence of 4.2 per cent,[3] were the most common abnormality in New York, and missing P_2 teeth (1.2 per cent) ranked second. The latter compared with 1.7 per cent for all developmental anomalies and 2.6 for all jaw and tooth anomalies combined, exclusive of maxillary canines in each case, and with 0.95 per cent for conditions involving injuries and infections.

Lueth (1969) termed missing P_2 teeth "the most common tooth anomaly" occurring in Alabama where it was found on "nearly one out of every one hundred jaws." However, Rees (1969), analyzing his data statistically, found the non-zero incidence of this anomaly to be 5 per cent for 23 mandibles from Ontario (Canada) and 12 per cent for 41 specimens from the George Reserve on Grand Island near Munising, Michigan.

Rees also found the non-zero incidence of supernumerary cusps on M_3 to be 3 per cent for 23 mandibles from Ontario (Canada) 2 per cent for 129 specimens from northern lower Michigan and 3 per cent for 49 specimens from Arizona.

Mech et al. (1970) found dental abnormalities in approximately 3 per cent of 401 jaws examined, eight among 142 wolf-killed deer

[3] This percentage was derived from the same 422-deer sample and represents 19 specimens that had maxillary canine teeth as described by Bergstrom et al. (1971).

and five among 259 hunter-killed deer. This compares favorably with the incidence in New York.

Injury-caused anomalies occur among deer generally, but relatively few are reported. Fractures can be caused by anything from falls to car accidents or bullet wounds, and bullet wounds are found wherever man is present. Impactions occur chiefly because of the coarse nature of browse food. This type of injury is found almost exclusively on the mandibular and not the maxillary tooth row.[4] Cowan (1946) theorized that this is due to "mechanics of jaw action coupled with the assistance of gravity in compressing food into any interstices in the lower row."

The frequency and consequences of anomalies due to actinomycosis or "lumpy jaw" are at present unknown. Cases of actinomycosis in "wild ruminants such as elk" were mentioned by Smith and Jones (1966), but no specific examples were given. Ryff (1953) reported a mule deer at Laramie, Wyoming, with encephalitis due to an infection of *Actinomyces bovis* but it is not known whether the infection originated in the jaw. Neiland (1970) reported that work with Dall sheep in Alaska indicated the presence of "lumpy jaw" infestations in the population but did not indicate the severity of the disease. In this case, the causative agent was not isolated. Karstad (1967) dealt with an area in which the deer were subject to high fluoride concentrations in the water. He recorded one specimen in which "the rear half of one of the first molars had broken away and this was associated with a roughened enlargement of the mandible suggestive of actinomycosis." Many other deer about 1 year old in this area had large bony prominences which were "either soft and cartilaginous or rough and pitted." This, too, suggests actinomycosis, but no positive identification was made by culturing for the *Actinomyces* micro-organism. It is not known, therefore, whether the fluoride itself caused these injuries or whether bacterial colonies were involved. Cowan (1946) reported having isolated *Actinomyces israeli* as the infectious organism in a dentoalveolar abscess, but this was only on one deer. This is the only "lumpy jaw" investigation, other than the present study, in which the pathogenic organism has been specifically isolated as *Actinomyces* spp. by culturing. The autopsy work done on actinomycosis was summarized by Stone (1970).

The majority of the mandibular and dental anomalies observed do not result in permanent disability or death of the deer affected. Missing, misplaced or broken teeth generally result in improper attrition (wear by friction of opposing teeth) and possibly some loss of digestibility of food due to improper mechanical breakdown. Broken jaws

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[4] On July 17, 1970, a 3-year-old doe, destroyed because of illness at the Delmar Exhibit Pens, was found, upon autopsy, to have a maxillary impaction in the area of M_2 and M_3 on the right side of the maxilla.

may rarely result in starvation of an animal; but usually, if this is the only broken bone, the injury amounts to only a temporary loss of condition and weakening until the fracture mends. Impactions themselves seldom cause important permanent disability either. The long range effects of an actinomycosis infection on a deer are unknown, and the "lumpy jaw" anomaly merits further study.

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KINETICS OF ROTENONE-POTASSIUM PERMANGANATE REACTIONS AS APPLIED TO THE PROTECTION OF TROUT STREAMS

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ABSTRACT

Rates of rotenone detoxification by potassium permanganate were estimated by arresting the reaction with tannic acid and estimating rotenone residues by bioassay. At rotenone concentrations up to 50 ppb (1 ppm 5 per cent emulsifiable product), detoxification occurs at a negative exponential rate directly proportional to the potassium permanganate concentration. Other rates are characteristic of higher concentration ranges. At any given rotenone concentration, detoxification time is inversely proportional to potassium permanganate concentration. Temperature has little effect on detoxification rates. Rates for given potassium permanganate and rotenone concentrations are slightly slower in hard than in soft water. Colloidal rotenone in saturated or freshly prepared dispersions is more difficult to detoxify than dissolved rotenone. Correction factors are given for hard water and for water containing organic material. Detoxification criteria are those for trout. Detoxification need not progress as far for centrarchids. Sodium thiosulfate may be used to treat toxic concentrations of potassium permanganate in streams.

Potassium permanganate ($KMnO_4$) detoxifies rotenone in water. This fact, discovered by Lawrence (1956), has been used in numerous stream-reclamation projects. It is assumed that a chemical reaction takes place, but the equation for the reaction remains unknown. Of published data on reaction rates, a study by Jackson (1957) showed that 1 ppm potassium permanganate will detoxify an approximately equal concentration of 5 per cent rotenone formulation within 24 hours. Several published reports of field observations made during stream treatments suggest a practically immediate detoxification.

Other properties of potassium permanganate dictate that it be introduced into natural waters with due care. It, too, is toxic to fish. Maximum concentrations tolerated by trout are in the neighborhood of 3 ppm in soft water and 1.5 ppm in hard water. Most other fish species appear to be more resistant. Since potassium permanganate is a strong oxidizing agent, it is readily broken down by reducing agents. Such treatment renders it non-toxic to fish at ordinary concentrations and prevents possible nuisance situations arising from its red color and tendency to stain laundry and plumbing.

The usual objectives of rotenone-potassium permanganate treatment are (1) removal of unwanted fish from a given stream segment and (2) protection of downstream populations of desirable fish from the toxic effects of rotenone. These ends can be attained by introducing potassium permanganate at a measured rate sufficiently high to completely detoxify the rotenone within a relatively short measured distance below the detoxification station. If the required concentration of

potassium permanganate should be above the tolerance limit for the fish to be protected, it would be necessary to introduce a safe reducing agent at a point sufficiently far downstream from the detoxification station to insure complete detoxification of the rotenone. Use of such a procedure requires a knowledge of stream velocities and transport dynamics and accurate estimates of the rates at which potassium permanganate detoxifies rotenone at various concentrations and under various conditions. To obtain the latter information, a study was conducted at the Department's Fish Laboratory at Livingston Manor, New York. The present paper describes the study, its results and the possible application of these results.

METHODS

Rotenone-containing dispersions of various concentrations were treated with various concentrations of potassium permanganate for various periods of time. At the end of the allotted time, tannic acid ($C_{76}H_{52}O_{46}$) was added and trout were placed in the dispersion. Residual rotenone concentrations were estimated from turnover times on the basis of a concentration-response curve (Loeb and Engstrom-Heg, 1971). All tests were conducted in 5-gallon glass jars, each containing 10 liters of water. Jars were partly immersed in aquarium tanks held at constant temperature. Dispersions were prepared by dilution of concentrated stock dispersions to the appropriate concentration. Except in tests specifically related to the "aging" of freshly prepared dispersions, the dispersions were held overnight (17-18 hours) before each test, to insure complete solution of the rotenone. In each test, trout were also placed in untreated control dispersions to confirm the validity of the concentration-response curve for the fish and rotenone formulation used. Test animals were yearling brown trout of Catskill Hatchery stock, weighing about 75 grams each. The fish had been acclimated for at least a week at the experimental temperatures and were not fed during the 48-hour period prior to an experiment. Rotenone concentrations ranged from 0.025 to 0.25 ppm (0.5 to 5 ppm of 5 per cent emulsified product). Potassium permanganate concentrations ranged from 1 to 10 ppm. Rotenone preparations used included Noxfish [1] and 94 per cent crystalline rotenone dissolved in acetone. Preliminary tests to measure the effectiveness and pinpoint any toxic effects of reducing agents, either alone or in combination with potassium permanganate and/or rotenone, were conducted in the same vessels, with fish of the same stock and under essentially the same conditions.

Hard water used in some tests was prepared by bubbling com-

[1] S.B. Penick and Company, Jersey City, N.J. Noxfish consists of: rotenone: 5%; other cube extractives: 10%; solvents and emulsifiers: 85%.

pressed carbon dioxide through a bed of calcite chips at the bottom of an aquarium tank of laboratory water, and subsequently removing free carbon dioxide by vigorous aeration.

RESULTS

The results of the various tests are presented separately.

Preliminary Tests on Reducing Agents

Preliminary tests on reducing agents lead to the following conclusions:

1. Tannic acid and sodium thiosulfate ($Na_2S_2O_3$) both reduce potassium permanganate quickly and efficiently. At a ratio of 2 parts tannic acid to 3 parts potassium permanganate, reduction to tetravalent manganese occurs within 15 seconds. Sodium thiosulfate, applied at a 1:1 ratio, is somewhat slower, but for field use it would be the preferred reducing agent because of its lower price.
2. Reduction of potassium permanganate immediately halts detoxification of rotenone. Noxfish dispersions to which potassium permanganate and tannic acid were added simultaneously did not differ measurably in toxicity from untreated dispersions.
3. Treatment with 6 ppm tannic acid or 10 ppm sodium thiosulfate does not measurably increase or decrease the toxicity of 0.1 ppm Noxfish dispersions.
4. Brown trout tolerate up to 10 ppm of tannic acid as well as the reaction products of at least 50 ppm of potassium permanganate treated with tannic acid at a 2:3 ratio.
5. Brown trout tolerate at least 100 ppm of sodium thiosulfate as well as the reaction products of at least 50 ppm of potassium permanganate treated with sodium thiosulfate at a 1:1 ratio.

Tests on Noxfish in Soft Water with Negligible Potassium Permanganate Demand

The tests were made with 1 ppm Noxfish (0.05 ppm rotenone). The water used was laboratory spring water (pH, 6.8; TDS, 23 ppm; alkalinity, 14 ppm) held at 65° F.

It was immediately evident that detoxification was not instantaneous. An extensive series of tests showed clearly that at any given potassium permanganate concentration, the logarithms of the residual rotenone concentrations formed a decreasing linear series when plotted against the potassium permanganate-rotenone contact time. Figure 1 shows a typical set of data for a series of contact times at a given potas-

sium permanganate concentration. It was evident that for each concentration, detoxification had occurred at a single negative exponential rate. Rates were computed for each concentration by curvilinear regression, using the original Noxfish concentration of 1 ppm at zero contact time as a fixed point of origin. Regression equations had the form $ln\ [n] = -kt$, where $[n]$ is the residual Noxfish concentration in ppm, t is the contact time in minutes and k is the rate constant. In terms of reaction kinetics, the reactions are of first order with respect to rotenone.

At a given potassium permanganate concentration, the contact time (T) required for detoxification to $[n] = 0.03$ ppm, the appropriate threshold concentration for brown trout (Loeb and Engstrom-Heg, 1971), can be obtained from a semilogarithmic plot by reading the intercept of the regression line with the time axis at $[n] = 0.03$ or by using the equation

$$(1) \quad T = \frac{ln\ ([N]/0.03)}{k} = \frac{ln\ 33.3[N]}{k}$$

where $[N]$ is the *original* Noxfish concentration in ppm.

When the rate constants (k) are plotted against corresponding potassium permanganate concentrations, the relationship is linear, indicating a direct proportion (Figure 2). Regression through a fixed origin, at $[KMnO_4] = 0$ and $k = 0$, yielded the equation

$$(2) \quad k = 0.067[KMnO_4]$$

where $[KMnO_4]$ is expressed in ppm. Equations (1) and (2) may be combined to give

$$(3) \quad T = \frac{ln\ 33.3[N]}{0.067[KMnO_4]}$$

Thus, at initial Noxfish concentrations up to 1 ppm, the rate constant is directly proportional, and the required contact time for detoxification is inversely proportional to the potassium permanganate concentration. Doubling the potassium permanganate concentration halves the required contact time. This simple, elegant relationship depends at least in part on the large excess of potassium permanganate over rotenone (20:1 to 200:1), which creates a situation in which the potassium permanganate concentration remains nearly constant throughout the reaction period. It would no doubt be invalid at low potassium permanganate-rotenone ratios. The equation is clearly applicable to Noxfish concentrations lower than 1 ppm, since a detoxifying dispersion must run through the full range of concentrations from 1 ppm to 0.03 ppm, and in all instances the log-linear relationship was maintained.

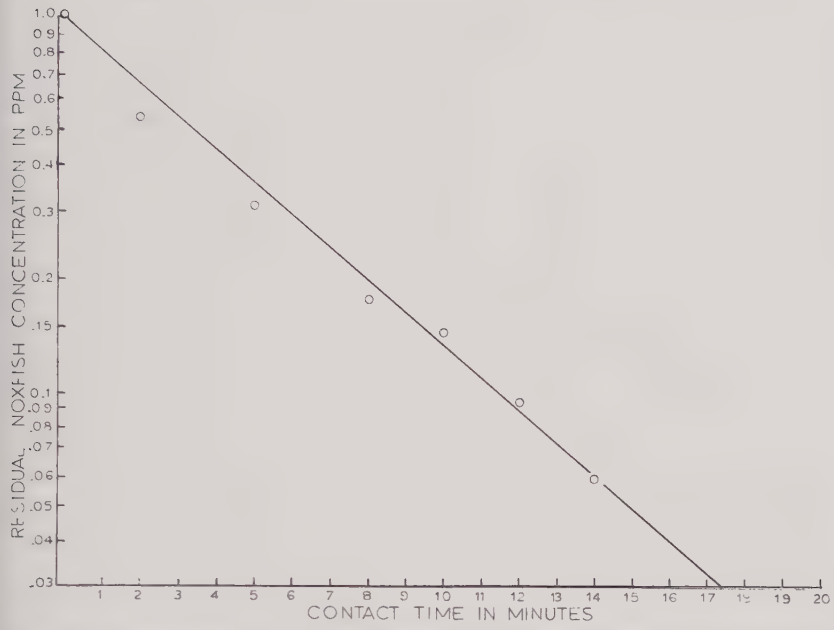

Figure 1. Detoxification of 1 ppm Noxfish by 3 ppm potassium permanganate. Equation for line: $ln[n] = -0.2t$, where $[n]$ is residual Noxfish concentration in ppm and t is contact time in minutes.

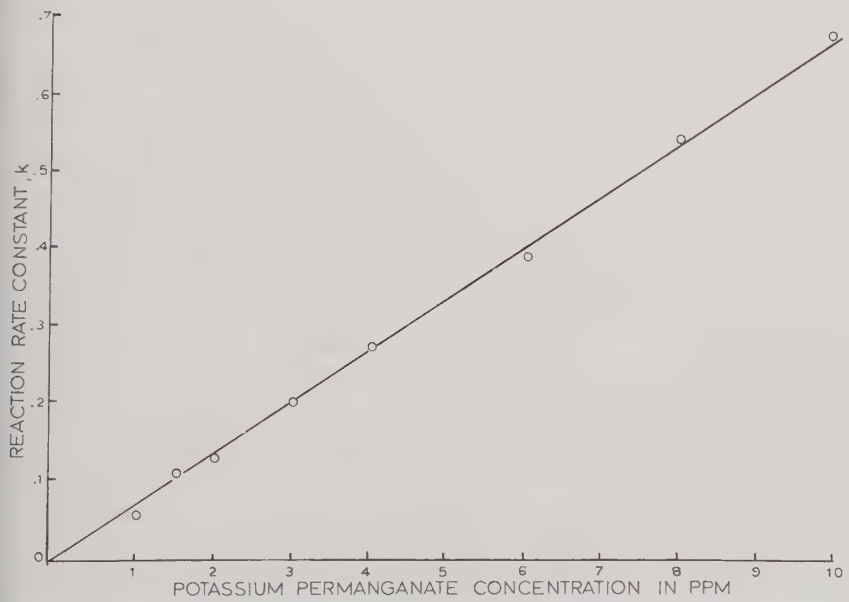

Figure 2. Regression of detoxification rate constants, $k = ln[n]/t$, against potassium permanganate concentration, $k = 0.067[KMnO_4]$.

Tests on Higher Rotenone Concentrations

Tests at 2 and 3 ppm Noxfish (0.1 and 0.15 ppm rotenone) in laboratory water showed that Equation (3) was not applicable at these concentrations. The early stages of detoxification were as predicted, but there was a low residual toxicity that did not disappear in the predicted time. The plot of this residual "tail" was linear on semilogarithmic paper, again indicating detoxification at a negative exponential rate, but at a slower one than that applying to the main body of toxicant (Figure 3). These test data can be explained by assuming the existence, in each part per million of Noxfish, of a second source of toxicity, having an initial toxicity value equal to 0.07 ppm Noxfish and undergoing detoxification at a rate described by the equation

$$(4) \quad T = \frac{ln\ 2.33[N]}{0.0154[KMnO_4]}$$

Such a toxicity source would be detoxified before rotenone at concentrations less than 1 ppm, but would be the factor controlling detoxification time at higher concentrations. Equation (4) corresponds well with data for 2 and 3 ppm Noxfish and for 0.1 ppm of crystalline rotenone. It was thought at first that this second source of toxicity might be one of the rotenoids present in the "other cube extractives" portion of Noxfish. However, the fact that crystalline rotenone followed the same pattern suggests that rotenone may detoxify in a stepwise manner, and that the first intermediate product may be a slightly toxic substance whose effects are evident at 2 ppm, but not at 1 ppm, Noxfish.

Gimlette (1923) found the solubility of rotenone in water to be approximately 0.16 ppm (equivalent to 3.2 ppm Noxfish). Data obtained by Cohen et al. (1960) tend to support the validity of this figure. At 4 ppm Noxfish (0.2 ppm rotenone), it might be assumed that rotenone would be present in both a dissolved and a colloidal phase. Tests on 4 and 5 ppm Noxfish dispersions indicated the presence of a much more persistent residual toxicity than occurred at 2 and 3 ppm (Figure 4). If it is hypothesized that dispersions more concentrated than 3.2 ppm Noxfish contain colloidal rotenone, and that colloidal rotenone is both less toxic (Loeb and Engstrom-Heg, 1970a) and less easily detoxified than dissolved rotenone, then the data for 4 and 5 ppm may be satisfactorily explained. Differences between residual toxicities at 4 and 5 ppm indicate a toxicity for colloidal rotenone equivalent to 0.14 ppm for each part per million of Noxfish. Using this value, a solubility of 3.2 ppm and the apparent detoxification rate for the residual "tail" at 4 ppm, the equation

$$(5) \quad T = \frac{ln\ 4.66\ ([N] - 3)}{0.00513\ [KMnO_4]}$$

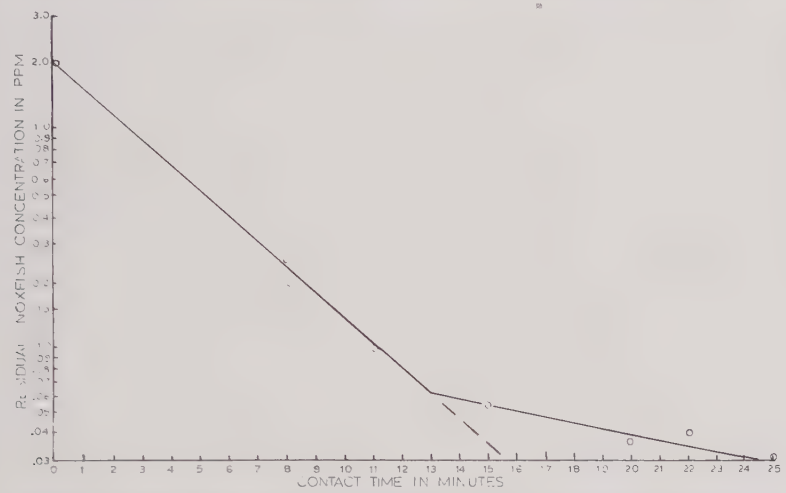

Figure 3. Detoxification of 2 ppm Noxfish by 4 ppm potassium permanganate. Detoxification at 15.7 minutes would be predicted from Equation (3).

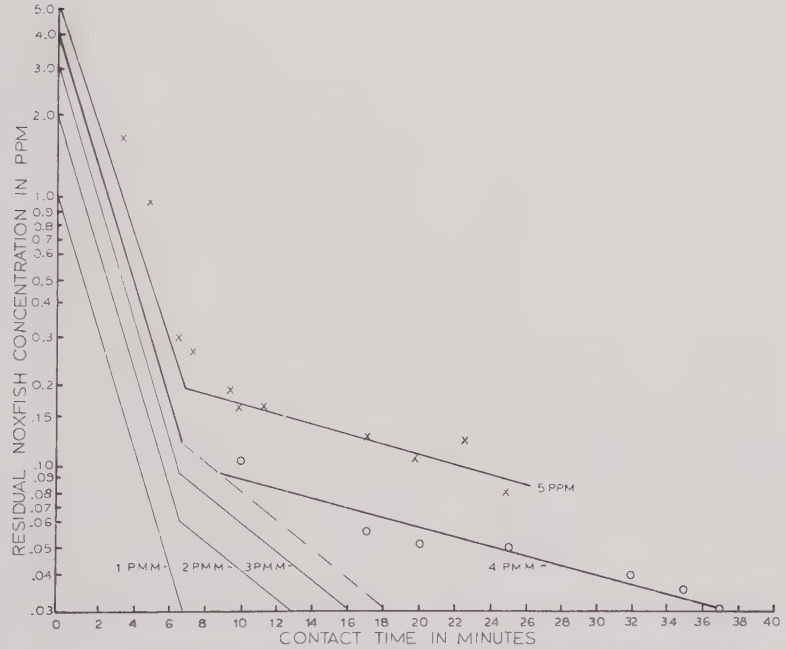

Figure 4. Detoxification of 4 and 5 ppm Noxfish by 8 ppm potassium permanganate. Slopes of residual "tails" correspond with Equation (5). Detoxification times for 1, 2 and 3 ppm Noxfish are also shown. Detoxification of 4 ppm in 18 minutes would be predicted from Equation (4).

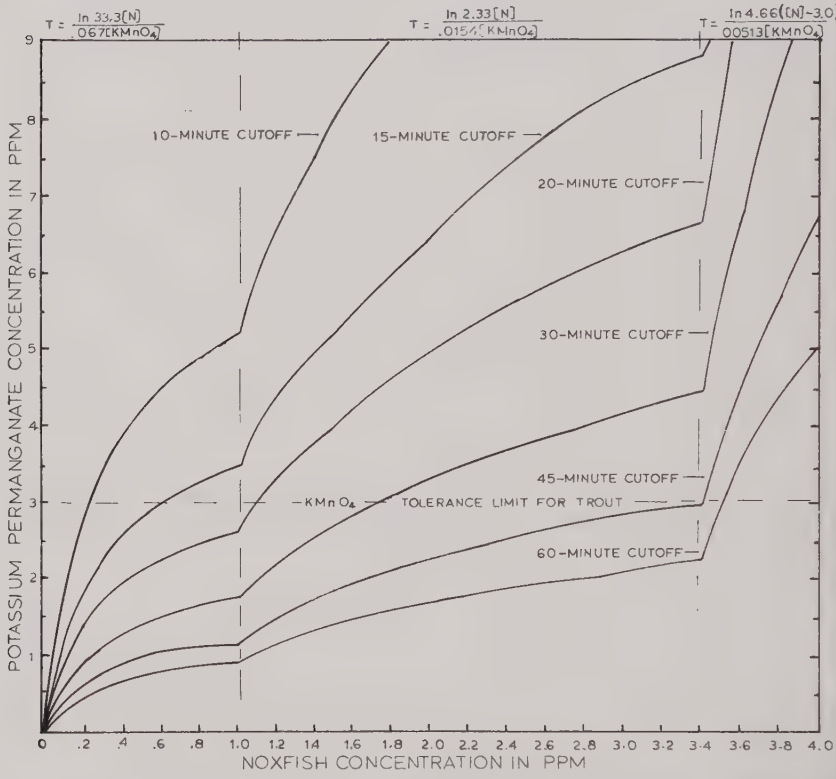
T = ln 33.3[N] / .067[KMnO4]
T = ln 2.33[N] / .0154[KMnO4]
T = ln 4.66([N]-3.0) / .00513[KMnO4]
10-MINUTE CUTOFF
15-MINUTE CUTOFF
20-MINUTE CUTOFF
30-MINUTE CUTOFF
45-MINUTE CUTOFF
60-MINUTE CUTOFF
KMnO4 TOLERANCE LIMIT FOR TROUT
POTASSIUM PERMANGANATE CONCENTRATION IN PPM
NOXFISH CONCENTRATION IN PPM
0 .2 .4 .6 .8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0
1 2 3 4 5 6 7 8 9

Figure 5. Relationship between Noxfish concentration, potassium permanganate concentration and contact time required for detoxification.

may be derived. This equation predicts that the colloidal rotenone concentration will become the factor controlling detoxification time at all concentrations above 3.5 ppm Noxfish (0.17 ppm rotenone).

Figure 5 shows the relationship between Noxfish concentration, potassium permanganate concentration and contact time required for detoxification to the threshold level for trout, over the full range of values studied. This chart may be used to find the potassium permanganate concentration needed to detoxify a given Noxfish concentration in a given period of time in soft water at temperatures at or near 65° F.

Tests on Freshly Prepared Dispersions

It was found that freshly prepared Noxfish dispersions did not detoxify completely within the predicted contact times for given concentrations of Noxfish and potassium permanganate. The detoxification pattern at 1 ppm resembled that for higher concentrations, indicating the presence of colloidal rotenone as hypothesized by Loeb and Engstrom-Heg (1970a). In still water, a lapse of 3 to 5 hours from

addition of Noxfish to addition of potassium permanganate was needed before detoxification could be obtained in the predicted contact time. When an electric stirrer was used to simulate the turbulent flow of a stream, solution was apparently complete in 1 to 2 hours for 1, 2 and 3 ppm Noxfish, as shown by detoxification within the predicted contact times. Subsequent tests in streams have shown that an hour of "aging" is sufficient to insure detoxification within the predicted time by a given potassium permanganate concentration for Noxfish concentrations up to 2.7 ppm in a pool-and-riffle stream of moderate gradient.

Influence of Temperature

At 47° F., a 1 ppm Noxfish dispersion was detoxified by 3 ppm potassium permanganate in 18.5 minutes. The corresponding figure for 65° F. was 17.5 minutes. Temperature evidently does not have an important effect on the detoxification rate. Since streams are usually reclaimed in the late summer or early fall, the equations based on data for 65° F. should be valid for practical field applications without any corrections.

Influence of Dissolved Electrolytes

Tests conducted at 65° F. with 0.8, 2.0 and 3.6 ppm Noxfish in hard water (pH, 7.8; TDS, 234 ppm; total alkalinity, 171 ppm; potassium permanganate demand, negligible) indicated (Table 1) that approximately 1¼ times as much potassium permanganate was needed to detoxify a given rotenone concentration in a given time in this water as in soft water. A satisfactory correction may be made by multiplying the required potassium permanganate concentration (from Figure 5)

Table 1. Detoxification of Noxfish in Hard Water *

Noxfish concentration in ppm	Potassium permanganate concentration in ppm	Contact time required for detoxification in minutes	Potassium permanganate concentration required for detoxification in same contact time in soft water in ppm	Ratio of concentrations required for hard water and soft water §
0.8	3.3	17.5	2.7	1.22
	4.0	15.0	3.3	1.21
2.0	6.5	20.0	5.0	1.30
	7.8	15.5	6.4	1.22
	8.45	15.0	6.6	1.28
3.6	9.4	30.0	6.8	1.38

* Total alkalinity, 171 ppm.
§ Mean ratio, 1.26.

by a factor equal to 1 + 0.002 (total alkalinity −20). Detoxification occurred within the predicted times when this correction was used to determine potassium permanganate concentrations needed to detoxify 1 ppm Noxfish in a series of dilutions of hard water with laboratory water.

Influence of Suspended Organic Material

Organic materials in colloidal or coarse suspension often reduce potassium permanganate. This is particularly true of humic materials in brown-stained water originating in swamps and bogs. Reduction by such materials is relatively slow compared with the action of tannic acid or sodium thiosulfate. Chlorine demand (Loeb and Engstrom-Heg, 1970b) measured over a 10-minute period, and potassium permanganate demand (Engstrom-Heg, 1971) measured over a period equal to the desired contact time, provided useful indices to the amount of such reducing material present in the stream water.

Jackson (1957) recommended that the potassium permanganate concentration needed for detoxification in chlorine demand-free water be increased by an amount equal to the chlorine demand. Since reduction of potassium permanganate is not immediate, and since the final potassium permanganate concentration would be that needed to detoxify the rotenone in the given contact time, it seemed likely that a smaller allowance for potassium permanganate demand would be adequate. Tests on soft stream water having a 10-minute chlorine demand and 20-minute potassium permanganate demand of 1.6 ppm revealed that 1 ppm Noxfish treated with 4.6 ppm of potassium permanganate was detoxified in 14 minutes. Corresponding values in water with negligible potassium permanganate demand were 17.5 minutes for 3 ppm and 11 minutes for 4.6 ppm potassium permanganate. In this same water, detoxification of 1 ppm Noxfish in 17.5 minutes was achieved with 3.4 ppm potassium permanganate.

Further tests were conducted with laboratory water in which the potassium permanganate demand had been artificially increased by adding measured amounts of instant tea. At 15-minute potassium permanganate demands of 2 and 5 ppm, 15-minute detoxification of 1 ppm Noxfish was achieved with 4.5 and 6 ppm respectively of potassium permanganate, representing in both cases the addition of an amount equal to half the potassium permanganate demand. Since the tea tended to reduce potassium permanganate somewhat more rapidly than corresponding amounts of naturally occurring humic materials, this would seem to be a safe allowance.

Discussion and Application

Application of these findings to actual treatment of streams de-

pends on fish management objectives, the physical and chemical characteristics of the stream to be treated, and the fish species present both in the treated section and in the protected area downstream from the detoxification station.

Rotenone concentrations used will depend on the target species. In general, it appears that 6-hour treatment with 1 ppm Noxfish (0.05 ppm rotenone) is sufficient to eradicate all common northeastern freshwater species except bullheads, goldfish and, possibly, large eels. In treating short sections of stream, there may be some advantage in using higher concentrations for a shorter period. However, there would seem to be no advantage in using concentrations above 3.5 ppm (0.17 ppm rotenone). Addition of more colloidal rotenone would not add greatly to the toxicity of the dispersion, but would make detoxification much more difficult. Streams should be treated in late summer or early fall because of the prevailing low stream flows and the greater effectiveness of rotenone at higher temperatures.

Potassium permanganate concentrations needed to detoxify a given rotenone concentration to the toxicity threshold for trout in a given time period can be obtained from Equations (3), (4), and (5) or from Figure 5. Appropriate correction factors can be applied for waters of high alkalinity and/or suspended organic content. Assume, for example, that a hard-water stream having an alkalinity of 220 ppm and a potassium permanganate demand of 2 ppm is to be treated with Noxfish that will arrive at the detoxification station at a concentration of 0.8 ppm. Detoxification in 20 minutes is desired. Reference to Figure 5 gives a value of 2.5 ppm potassium permanganate. The alkalinity correction is made by multiplying this figure by 1 + (200) (0.002) or 1.4, i.e., $2.5 \times 1.4 = 3.5$ ppm. The potassium permanganate demand correction is 2 ppm $\div$ 2 = 1 ppm. The desired concentration would then be 4.5 ppm of potassium permanganate. No temperature correction is needed. This concentration would, of course, require the use of a reducing agent.

The length of the transition zone below the detoxification site depends on stream velocity. Detoxification will be complete in a much shorter distance in a sluggish stream than in a rapid one. If a reducing agent is used, it is important that the downstream limit of rotenone toxicity be located and that the reducing agent be introduced below this point. This may be done by following the leading edge of a bolt of tracer material, either salt or dye. In the previous example, the reducing agent could be introduced at a point 20 minutes downstream from the potassium permanganate station, measured by this method. All rotenone passing this point will have had *at least* 20 minutes contact with potassium permanganate, and the residual rotenone concentration will be safely below the threshold value for trout.

Rotenone treatment of very short sections of trout streams for sampling purposes is probably impractical except where stream velocities are very low. In general, the last toxicant station in any treated section should be far enough upstream from the potassium permanganate station to allow the rotenone to dissolve completely. Presence of a colloidal residue could be troublesome.

Since trout are among the most rotenone-sensitive of fish, treatment of non-trout waters should entail fewer problems. Most centrarchid species tolerate about three times as much residual rotenone as do trout, and most other freshwater fish are still more tolerant. Hence, a given potassium permanganate concentration will detoxify a stream for bass and sunfish in a markedly shorter distance than for trout. It seems likely that, in centrarchid waters, the effects of low residual "tails" could be ignored and that an equation similar to (3), but based on the threshold concentration for the most sensitive species, could be used for all rotenone concentrations. In field tests, very few fish other than trout were observed to be in distress at any distance downstream from the potassium permanganate station.

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ESTABLISHING BREEDING COLONIES OF REDHEADS IN NEW YORK BY RELEASING HAND-REARED BIRDS [1]

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ABSTRACT

In 1952 redhead eggs were obtained from Delta, Manitoba. Fifty young, hatched from these eggs, were released at 5 weeks of age and appear to have established a breeding colony at one of the sites involved. The remaining young were held for developing a redhead breeding stock on the State game farms. From this stock 1,972 ducklings and 1,911 adults were released between 1957 and 1963. Adults and ducklings were tried in many habitats, but only one additional colony was established. Some stock returned in spring but did not persist. Band recoveries and retrap records suggest the migration, longevity and homing of these redheads.

In 1952, through the courtesy of the Canadian Wildlife Service and the Delta Waterfowl Research Station, redhead eggs were collected in Manitoba and transported to New York State where they were hatched at the Delmar Game Farm. Fifty ducklings were released at 5 weeks of age. The remainder were kept to develop the breeding stock that provided the birds for this study.

DUCKLINGS RELEASED IN 1952

Survival of the redheads released in 1952, and of other species obtained at the same time, was reported on variously by Foley (1954a, 1954b, 1961). Of the 50 redhead ducklings, 20 were released on the Oak Orchard Game Management Area and 10 on Blood Marsh (both in Genesee County) and 20 on the Montezuma National Wildlife Refuge in Cayuga County. No records were obtained on survival at Oak Orchard, but one returning pair was observed in 1953. One young survived to the flight stage at Blood Marsh, but no later observations were made. At Montezuma, 13 young survived until able to fly and subsequent records seem to indicate the establishment of a breeding colony.

DUCKLINGS AND ADULTS RELEASED AFTER 1952

No further releases of redheads were made in New York until 1957 while the game farms were developing a breeding stock. Ducklings were released in 1957 and 1958 and again in 1960 and 1961, all at approximately 5 weeks of age. The total number was 1,972. None was

[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-39-R.

released in 1959 because of the poor condition of the stock; bumble-foot with its associated streptococcus infection and resulting heart lesions served to keep the game farm birds too thin.

Two adults were released in 1957, but the principal release program with respect to adults began in 1958 when game farm production was well under way. Some of those released in the spring of 1959 were in poor condition, apparently because of bumble-foot disease, and few birds were available in the spring of 1960 because of the problems in 1959. A total of 1,911 adults were released from 1957 to 1963 when the study was terminated because of its relatively slight success.

SURVEYS OF RELEASED DUCKLINGS

Table 1 shows the number of ducklings released each year and the number of groups involved, together with survival to the flight stage where it was possible to follow the groups. The survival to flight stage of 64.4 per cent of 567 ducklings followed was very encouraging. A similar survival of 61 per cent for mallards was reported by Foley (1954a). Field surveys from 1938 through 1941 showed a 51.6 per cent survival for 399 released 5 week-old mallards (Foley et al., 1961). Probably this lower figure is more realistic for it included birds that by chance encountered more vagaries of weather and environment. Since the redhead ducklings spent more time in open water and deep marshes than did the mallards, higher survival could be expected. One group of redheads, in which 73 per cent of 92 young survived, used loafing and preening areas in open water and rarely approached shore.

Redheads on the game farm did not start laying until the middle of May, and laying did not reach a peak until early June. No young were available as 5 week olds until the last week of July, and most releases were made in August. Few young were seen flying until they

Table 1. Redhead Ducklings Released from 1957 to 1961 and Observed Survival

Year	Number released *	Number of groups	Ducklings subsequently followed		
			Number	Survival to flight stage	
				Number	Per cent
1957	263	5 §	260	163	62.7
1958	431	14	231	157	68.0
1960	409	12	76	45	59.2
1961	869	32	..	..	..
Total	1,972	63	567	365	64.4

* All ducklings released were 5 weeks old (plus or minus a few days) except the Oak Orchard group in 1960 of which 76 were 6 weeks old.

§ Includes three ponds at Oak Orchard, the marsh at Perch River and a pond at Three Rivers.

were 11 weeks old. As a result many were not ready to start exploratory flights until late September.

Dispersal can best be studied through band recoveries, but field observations suggest behavior. In 1957 the ducklings released on the Oak Orchard and Perch River Game Management Areas were observed on local exploratory flights but appeared to keep the home marsh as base. Many birds were still present when the hunting season opened, and some remained into November. In 1958 at Oak Orchard, the birds released were not much in evidence after attaining flight and only a few were present after the season opened, but 26 per cent of the band recoveries were local compared with 30 per cent in 1957.

Checks for returning stock were strictly observational; no bands were examined to determine the origin of birds present. In the spring of 1958, one pair of redheads was seen at Perch River and was reported to have reared a brood. One male and two females were seen at Oak Orchard but no young were produced. No stock was observed at the Three Rivers Game Management Area. No birds were observed in 1959 that seemed to represent ducklings released in 1958. No ducklings were released in 1959. In 1961 the only adequate checks were made at Montezuma. There an increase in the number of redhead broods was observed. This might possibly be attributed to ducklings released in 1960, but it could just as logically have resulted from better nesting success or more complete surveying of an already existent flock. In 1962, three broods of redheads were observed at Oak Orchard, but these seemingly were the product of the breeders released in 1962 rather than returning duckling stock.

SURVEYS OF RELEASED ADULTS

Table 2 shows the number of adults released each year and subsequent field observations involving 432 pairs at 69 sites that were followed through the breeding season. The most intensive observations were made during 1958, 1959 and 1960. In 1959, project personnel were assisted by regional personnel in giving good coverage to the many small release groups; but only three redhead broods were identified by technicians, although five others were reported that appeared valid.

Releases of adult redheads were made near mid-April each year. At this time, all the water areas being used were largely free of ice and it was felt that food should be adequate. The earliest releases were made April 5 in 1962, and in that year at least 5 of 20 birds put on one area died of starvation. No other cases of starved birds were seen, but, since there was such a sharp transition from feeding on the ever-present game farm supplies to searching for natural foods, it is possible that some of the redheads may have been in too poor physical condition to lay eggs. In mallard studies it was found that birds re-

Table 2. Adult Redheads Released from 1957 to 1963 and Pairs Subsequently Observed

Year	Number released	Pairs subsequently observed		
		Number	Sites	Broods produced
1957	2	..	..	..
1958	158	75	6	1
1959	624	191	58	3 (5) *
1960	49	24	2	1
1961	134	..	..	..
1962	319	50	1	3
1963	625	92	2	..
Total	1,911	432	69	8

* Three broods were definitely identified, while five others were reported but not verified by project personnel.

leased under poor feeding conditions sometimes delayed nesting 2 to 3 weeks beyond the expected date; meanwhile, some birds released later had already begun nesting.

In 1958 the birds were clipped when put out and were not observed flying until July. In 1959, primary stubs were pulled March 25. At release time on April 8 new quills were well started and by April 20 some seemed nearing flight stage. However, it was nearly mid-May before any birds exhibited sustained flight. Females tried their wings more and achieved sustained flight nearly a week ahead of the males. Nearly all the birds released in 1959 on small marsh units disappeared before the end of June. On large marshes such as those at Oak Orchard they were in evidence longer.

In both 1958 and 1959, the released birds tended to stay in compact flocks as long as they were in evidence at all. Pairing within the flock was characteristic, but pair bonds seemed much stronger in 1959 when the flocks were smaller. Flocks almost invariably were noted feeding or loafing in the more open habitat. During the three intensive years of study only 8 of 290 pairs seemed to demonstrate strong territorialism.

Habitat used in these studies included large and small units, embracing marsh, swamp, open water and even bog environment. For practical purposes all the types of duck habitat in upstate New York were tried. Refuge areas as well as those open to hunting were included. Seemingly, only Montezuma and Jamaica Bay approached the redheads' needs and desires. At Oak Orchard and Wilson Hill there were years when the areas appeared to be suitable. But in other years, because of basic changes due to recent flooding along with fluctuating waterlevels and sometimes excessive carp action, the environment did not seem adequate. None of the small units lured the redheads back permanently.

SUCCESS IN ESTABLISHING COLONIES

Verbal accounts indicate that at least one pair of redheads had been observed through the summer at Montezuma shortly after the original flooding in the late 1930's, but that none was seen in the years immediately before 1952. In 1953, three pairs were observed and apparently 13 young in two broods were reared. No broods were reported in 1954, but from 1955 to 1963 refuge records showed 4, 2, 2, 2, 4, 3, 13, 8 and 17 broods, successively. More than 200 young were believed to have been reared in 1963. Seemingly a breeding colony was established at the Montezuma Refuge, and the redheads found the extensive areas of cattail and bulrush adequate habitat. No banding records are available to prove that this stock developed from the ducklings released in 1952, but circumstantial evidence is strong. By 1970, the population had dwindled and only two broods were produced, probably because of a die-off of cattails and the gradual incursion of purple loosestrife.

At Oak Orchard the presence of three broods in 1962 was a hopeful sign, but with the cessation of stocking there was no further evidence of redheads in the breeding population. Unlike what happened at Montezuma, even the locally hatched young did not create a permanent establishment.

At Wilson Hill the redheads that returned in 1960 seemed even more hopeful. In May, 15 to 20 pairs were located, most of which apparently were on territory. The birds that had been released on the area included 50 ducklings in 1958 and 10 pairs of adults in 1959. At least two broods were produced in 1959, and an early fall flock of over 50 birds suggested more young may have been produced. But summer surveys located only one brood in 1960, two in 1961 and three in 1962. Since then no more broods have been located and the prospect of a colony disappeared. Perhaps, however, the loss was not complete. In 1961 Gaston Moisan of Laval University at Quebec indicated (personal conversation) that he had found 20 pairs of redheads breeding in the Lake St. Francis marshes on the St. Lawrence River. He believed this was a new colony or a much expanded previous one. Band recoveries indicated that some of the birds released at Wilson Hill moved to that locality, and Dr. Moisan said at least 7 of 25 redheads shot there in 1961 were from Wilson Hill. Redheads released at other New York sites also were recovered in the Lake St. Francis vicinity.

The least watched site produced the best results. At the Jamaica Bay Wildlife Sanctuary 50 ducklings were released in 1958, and 48 in 1960. No regular surveys were made to follow these birds, but broods have been reported yearly since 1962. In 1967 there were nine broods of redheads observed on a 40-acre freshwater pond. Jamaica Bay itself is tidal.

It may be significant that both the Montezuma and Jamaica Bay

colonies were started from releases of ducklings. No colonies were started from releases of adults. A possible exception might be the colony on Lake St. Francis which may have resulted from released adults or may not have been from New York stock.

BAND RECOVERY AND MORTALITY

Observational surveys indicated good survival to the flight stage for ducklings and most groups of adults. However, band recovery data are required to show mortality from that time on.

Band recoveries during the first hunting season showed significant differences (at the 1 per cent level) in vulnerability between adults and immatures (Table 3). No significant differences were observed between sexes within each age group.

The birds were released on many sites in the State, but it was not possible to make releases of both age groups on all sites during the same year. Since the hunting season and habitat also varied from year to year and from place to place, no more than a gross analysis can be made of the effect of release location on survival. Accordingly, eight areas were designated on the basis of geography and gross ecological

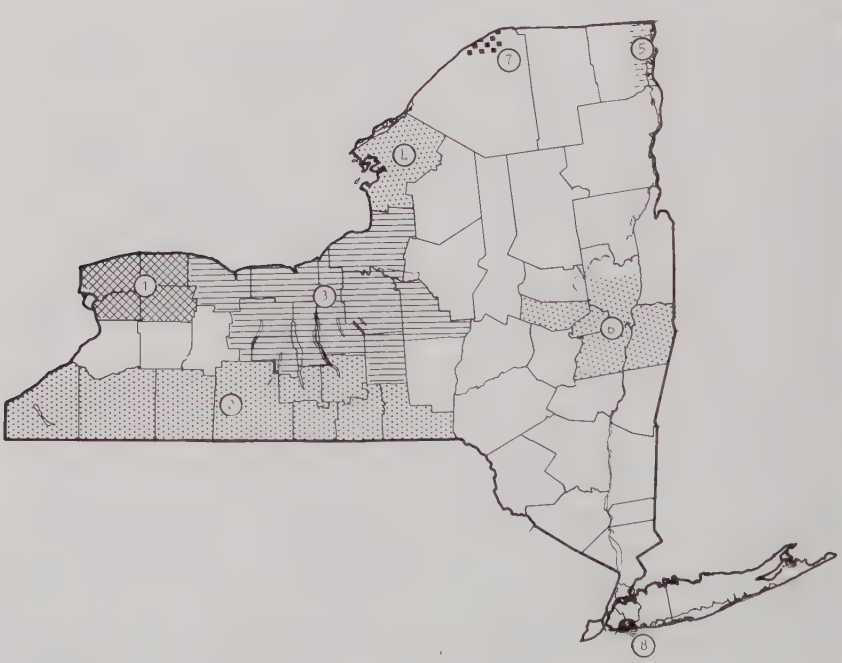

Figure 1. Areas of the State designated as having different habitat characteristics with respect to the sites where hand-reared redheads were released. Area 7 is the Wilson Hill Game Management Area, and Area 8 is the Jamaica Bay Wildlife Sanctuary.

TABLE 3. COMPARATIVE VULNERABILITY TO HUNTING DURING FIRST OPEN SEASON, ACCORDING TO AGE AND SEX, FOR HAND-REARED REDHEADS RELEASED IN NEW YORK

Age	Sex	Number released	Recoveries during first hunting season		Vulnerability to hunting * (relative to adult females)
			Number	Per cent	
Immature	Male	973	154	15.8	2.1
	Female	1,049	171	16.3	2.2
Adult	Male	1,048	91	8.7	1.2
	Female	863	64	7.4	1.0
Total		3,933	480	12.2	xxx

* The differences between sexes within each age group are not significant. The difference between age groups (sexes lumped) are significant at the 1 per cent level of probability.

TABLE 4. RATE OF BAND RECOVERY DURING FIRST HUNTING SEASON FOR REDHEADS RELEASED IN NEW YORK

Area §	Immature			Adult		
	Number released	Bands recovered		Number released	Bands recovered	
		Number	Per cent		Number	Per cent
1	361	71	19.7	241	22	9.1
2	100	10	10.0	108	11	10.2
3	575	77	13.4	1,167	59	5.1 *
4	497	85	17.1	182	39	21.4 *
5	70	12	17.1	30	7	23.3 *
6	72	3	4.2 *	163	13	8.0
7	249	64	25.7	20	4	20.0
8	98	3	3.1 *	0	..	..
Total	2,022	325	16.1	1,911	155	8.1

§ See Figure 1.
* Indicates significant difference from average for age group at 5 per cent level of probability.

type (Figure 1). The first-year band-recovery rates for birds released in each of these areas are shown in Table 4. In each area, some releases were made during years when hunting for redheads was permitted and some during years when it was not. Some statistically significant differences occurred. Most releases in areas where high recovery rates occurred were made on or near public hunting areas, e.g., the Perch River and Wilson Hill Game Management Areas in Region 4 and the Ausable Game Management Area in Region 5. The extremely low rates occurred when the bulk of releases were made during a year in which the season was closed on redheads (adults in Region 3), on a

TABLE 5. MORTALITY, AS INDICATED BY BAND RECOVERY DATA, FOR IMMATURE AND ADULT HAND-REARED REDHEADS RELEASED IN NEW YORK DURING YEARS IN WHICH HUNTING FOR THIS SPECIES WAS PERMITTED IN THIS STATE

Year	Number released	Total number recovered	Rate of direct recovery (per cent)	Number recovered, according to number of years after banding *									
				Direct	Indirect								
				(0-1)	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10
Immature													
1952	50	10	16.0	8	2	0	0	0	0	0	0	..	..
1957	263	77	27.4	72	3	2	..	..	..	..	0	0	0
1958	431	110	22.3	96	9	1	..	1	..	1	1	0	1
Total	744	197	23.7	176	14	3	0	1	0	1	1	0	1
Yearly mortality (per cent) §				89.3	7.1	1.5	0.0	0.5	0.0	0.5	0.5	0.0	0.5
Mortality rate (per cent) †				89.3	45.7								
Adult													
1957	2	0	0.0	0	0	0	..	..	..	..	0	xxx	xxx
1958	158	36	22.2	35	0	..	1	..	..	0	0	xxx	xxx
1959	624	95	13.3	83	7	1	..	1	2	0	1	xxx	xxx
Total	784	131	15.1	118	7	1	1	1	2	0	1	xxx	xxx
Yearly mortality (per cent) §				90.1	5.3	0.8	0.8	0.8	1.5	0.0	0.8	xxx	xxx
Mortality rate (per cent) †				90.1	39.4								

* Year designations based on zero as year of banding and include two years (i.e., 1-2) because banding was done in middle of calendar year. Numerals in bold face and blanks indicated by dots for a given release group represent years in which hunting for redheads was prohibited in the United States.

§ Represents mortality each year based on total number recovered.

† For indirect recoveries, represents average of the rates of loss for the several years based in each case on the number surviving to that year. (After Williams, 1967 — page 160, Method 1)

TABLE 6. MORTALITY, AS INDICATED BY BAND RECOVERY DATA, FOR IMMATURE AND ADULT HAND-REARED REDHEADS RELEASED IN NEW YORK DURING YEARS IN WHICH HUNTING FOR THIS SPECIES WAS PROHIBITED IN THIS STATE

Year	Number released	Total number recovered	Rate of direct recovery (per cent)	Number recovered, according to number of years after banding *					
				Direct	Indirect				
				(0-1)	1-2	2-3	3-4	4-5	5-6
Immature									
1960	409	34	7.3	**30**	**2**	..	..	**1**	**1**
1961	869	137	13.8	**120**	**8**	**2**	**2**	3	2
Total	1,278	171	11.7	150	10	2	2	4	3
Yearly mortality (per cent) §				87.7	5.8	1.2	1.2	2.3	1.8
Mortality rate (per cent) †				87.7	41.2				
Adult									
1960	49	3	6.1	**3**	..	..	..	**0**	**0**
1961	134	15	9.7	**13**	**1**	..	**0**	**0**	**1**
1962	319	28	5.6	**18**	**1**	**5**	**3**	**1**	**0**
1963	625	73	2.6	**16**	33	15	5	4	0
Total	1,127	119	4.4	50	35	20	8	5	1
Yearly mortality (per cent) §				42.2	29.4	16.8	6.7	4.2	0.8
Mortality rate (per cent) †				42.2	55.6				

* Year designations based on zero as year of banding and include two years (i.e., 1-2) because banding was done in middle of calendar year. Numerals in bold face and blanks indicated by dots for a given release group represent years in which hunting for redheads was prohibited in the United States.

§ Represents mortality each year based on total number recovered.

† For indirect recoveries, represents average of the rates of loss for the several years based in each case on the number surviving to that year. (After Williams, 1967 — page 160, Method 1)

refuge area (Jamaica Bay) or in a locality where redheads did not usually occur in large numbers (Region 6).

Tables 5 and 6 present mortality and band recovery data according to the age of the birds at the time of release and also according to whether or not the hunting season was open or closed on redheads in the United States during the fall following release. For birds released during years having an open season, there was no significant difference in first-year mortality between adults (90.1 per cent) and immatures (89.3 per cent). These figures do not differ greatly from those reported by Hickey (1952) for wild redheads (87 per cent) and by Weller and Ward (1959) for hand-reared redheads released at Delta, Manitoba (86 per cent).

For immature birds released in 1960 and 1961 when they were protected in the United States, the first-year mortality did not decrease. The band recovery rate decreased, however, indicating that probably

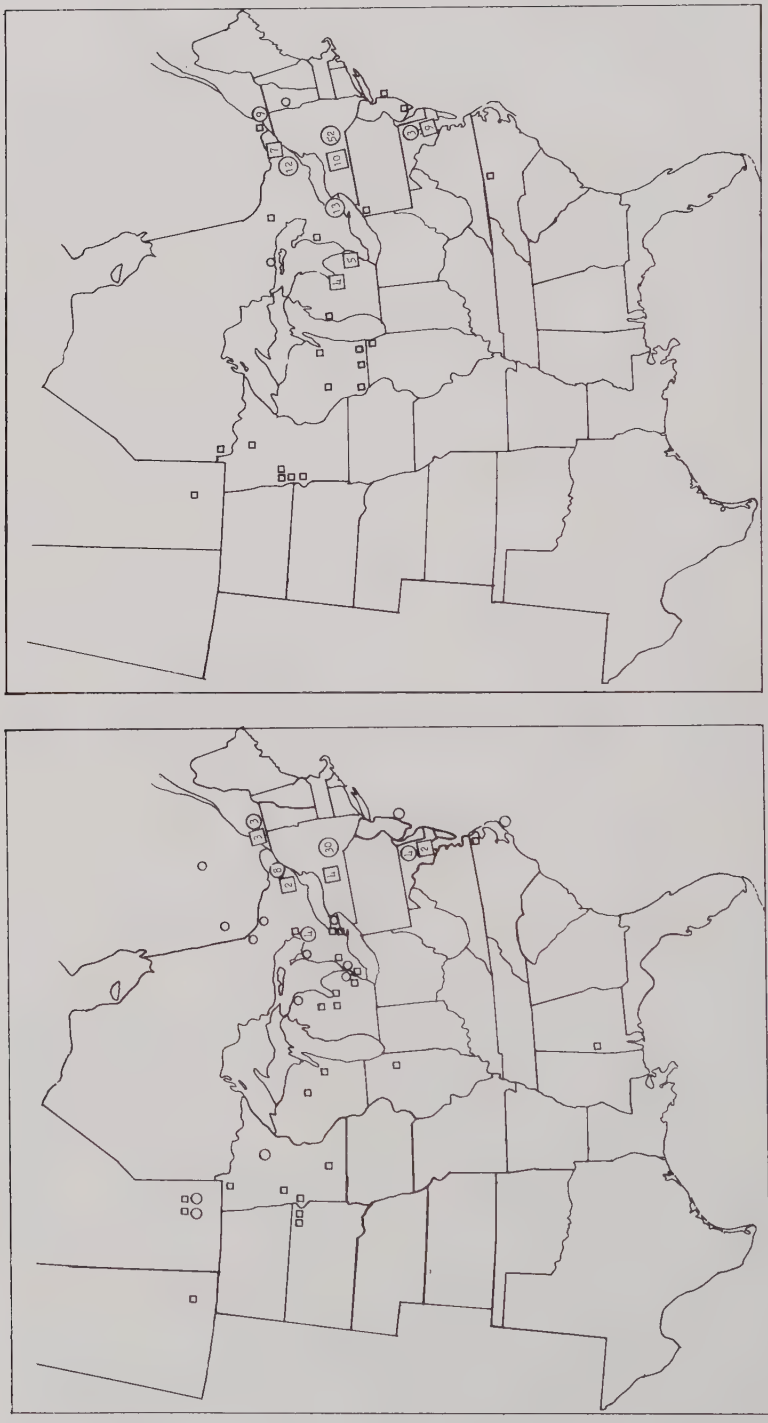

Figure 2. Direct (circles) and indirect (squares) recoveries of adult hand-reared redheads released in New York: (left) females; (right) males.

Figure 3. Direct (circles) and indirect (squares) recoveries of imature hand-reared redheads released in New York: (left) females; (right) males.

Table 7. Distribution of Subsequent Recoveries by Hunting for Hand-reared Redheads Released in New York in 1952 and from 1957 to 1963 and Retrapped in New York During the Months of January to March through 1966

Age	Sex	Number released	Number retrapped *	Subsequent recovery by hunting					
				Years §				Location †	
				0-1	1-2	2-3	3-4	First year	Later years
Immature	Male	973	20	..	..	..	1	..	N.C. (1)
	Female	1,049	14	..	1	..	..	..	Ont. (1)
Adult	Male	1,048	93	6	9	2	1	Minn. (1) Mich. (2) Ont. (2) N.Y. (1)	Man. (1) Minn. (1) Wisc. (1) Mich. (3) Ont. (2) Que. (1) N.Y. (2) Md. (1)
	Female	863	87	8	2	1	..	S.D. (1) Minn. (2) Wisc. (1) Mich. (1) Ont. (1) N.Y. (2)	S.D. (1) Mich. (1) Que. (1)
Total		3,933	214	14	12	3	2	xxx	xxx

* These records not included in Figures 2 to 6.
§ See Table 5.
† Of these recoveries, 71.0 per cent came from north and west of New York.

many were shot illegally but not reported. Part of the reason for the stable mortality was that they were not protected in the provinces of Ontario and Quebec. It has been well documented that young redheads tend to wander northward in late summer. Thus, from 1952 to 1959 when hunting for redheads was permitted in the United States, 42.2 per cent of the first-year recoveries of immatures were in Canada. In contrast, for 1960 and 1961 when the season for redheads was closed in the United States, the figure was 83.3 per cent. That this is largely a phenomenon of young birds is shown by comparable figures, 33 per cent in 1958-1959 and 45 per cent in 1960-1963, for adults which were recovered in Canada.

Among adults released from 1960 to 1963, the first-year mortality rate was less than half what it had been in 1958 and 1959. This was partly because fewer adults went to Canada and partly because over half the releases of adults during this period were made in 1963 when redheads were protected in both Canada and the United States.

Benson and DeGraff (1968) showed that redheads wintering in New York are most closely associated with the breeding areas of

Figure 4. Direct (circles) and indirect (squares) recoveries of immature wild redheads banded at the Montezuma National Wildlife Refuge.

Manitoba and Minnesota. Apparently there was also a strong tendency for hand-reared redheads released in New York to go to these areas to breed. This can be seen graphically in Figures 2 and 3 and in Table 7. Especially interesting are the three direct [2] recoveries of adult females from the traditional breeding areas (Figure 2). Releases of adults were made near mid-April, but the birds were flightless until well after the wild migration had past. The distribution of indirect [2] recoveries was essentially similar for all ages and sexes with some recoveries from each group coming from the Manitoba-Minnesota breeding areas, along the traditional migration routes and from the New York and mid-Atlantic wintering areas.

Of the 3,933 redheads released, 214 were later recaptured at winter banding stations where wild redheads are banded in New York. For wild redheads banded at about the same time and place, 56.5 per cent

2 A "direct" recovery is one that occurs between the time a bird is banded and the end of the first succeeding hunting season. An "indirect" recovery is one that occurs after that time.

of the recoveries came from north and west of New York (Benson and DeGraff 1968, Table 7), while 71 per cent of 31 recoveries from the 214 birds retrapped in the present study came from this sector.

Redheads hatched wild in the Montezuma colony have shown a tendency toward a similar dispersal. Some ducklings have been captured there by night-lighting. Only nine direct and six indirect recoveries are available from these bandings, but they show the northward wandering and some westward dispersal (Figure 4).

The high first-year mortality, especially among immature birds, and the tendency for hand-reared redheads to return to the traditional breeding grounds of the species apparently were large factors in the failure to establish more colonies in New York.

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NET DAMAGE AND SUBSEQUENT MORTALITY FROM FURUNCULOSIS IN SMALLMOUTH BASS [1]

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ABSTRACT

To determine if trap netting was related to the occurrence of lesions and furunculosis in smallmouth bass, bass were netted in Wilson Bay (Lake Ontario) and placed in a holding net, after which, at different intervals, sample fish were transported to the Cape Vincent Fisheries Station for further observation and subsequent analysis. The findings indicate that the causative agent of furunculosis (*Aeromonas salmonicida*) can be contracted by smallmouth bass held in trap nets for 2 to 10 days and that the longer they are held the greater the probability.

Since 1966, investigations of smallmouth bass (*Micropterus dolomieui*) in eastern Lake Ontario have been conducted by personnel from the State Department of Environmental Conservation Fisheries Station at Cape Vincent, New York. Intensive open lake studies have been confined to the Wilson Bay and Hardscrabble areas (Figure 1). A large portion of this work entailed trap netting adult bass in the spring for the purpose of tagging and data collecting.

Both of the study areas lie within the bounds of the Chaumont Bay commercial fishery, which include waters within ½ mile of shore, and bays, from the Tibbetts Point Light to Horse Island (Figure 1); however, only the Hardscrabble area supports any appreciable commercial fishing. There are from 12 to 18 licensed commercial fishermen, and they harvest approximately 250,000 pounds of fish worth $60,000 annually. The most important species, on an economic basis, are the American eel (*Anguilla rostrata*) and brown bullhead (*Ictalurus nebulosus*). The primary method of harvest is the Lake Oneida trap net, similar to those used by station biologists.

Prior to 1968 the Chaumont Bay commercial fishery opened on

[1] The authors wish to thank Drs. John Forney and Richard Noble of the Cornell Biological Field Station at Shackleton Point for assistance in setting up the project. As work progressed, Richard Dumas, senior aquatic biologist at the Department's Fish Pathology Laboratory at Rome handled some phases of isolation of the disease organisms. We owe a special thanks to Dr. Douglas S. Robson of the Biometrics Unit at Cornell University who helped with the statistical analysis of the data. We also thank Dr. Paul Neth and Donald Pasko of the Department of Environmental Conservation for their critical review of the manuscript and suggestions.

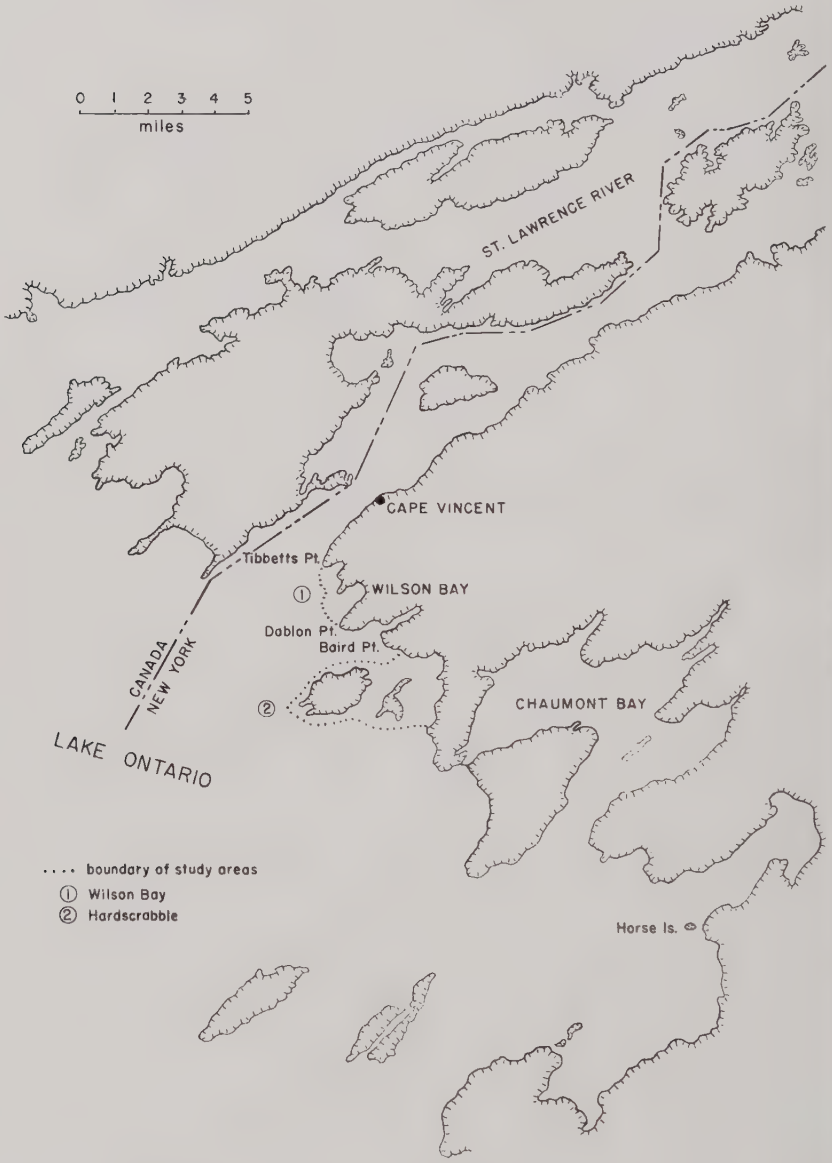

Figure 1. Location of smallmouth bass study areas in eastern Lake Ontario. Commercial fishing area extends from Tibbetts Point to Horse Island, within ½ mile of shore.

September 15 and closed on May 15. In 1968 the closing date was extended to May 28 to allow fishermen to harvest more eels. Commercial fishermen began catching large numbers of smallmouth bass, which generally begin their spawning run during the middle of May. Station

biologists, in 1968 and 1969, tagged smallmouth bass taken from commercial nets in the Hardscrabble study area to determine movement patterns and exploitation.

Biologists handling smallmouth bass from these commercial nets noted a high incidence of fish with open sores, i.e., scales missing and lesions. This was not the case with smallmouth bass handled in Wilson Bay in any year or in the Hardscrabble area before 1968. Also letters from fishermen and tag return data indicated that a considerable number of bass were found dead soon after netting and tagging were terminated. Apparently the commercial fishing activities were affecting the smallmouth bass population.

In May 1969, a sample of six fish exhibiting lesions was removed from a commercial trap net and sent to the Fish Pathology Laboratory at Rome (N.Y.) for analysis. On delivery the bass were placed in aquaria for continued observation, and four of them died within 3 days.

Lesions of bass examined varied from whitish discolorations with the dermis intact to shallow, hemorrhagic sores which, for the most part, did not completely penetrate the integument. There was practically no scale denudation in these latter areas which varied roughly from 2 to 10 millimeters in diameter. Distribution over body surfaces was nonspecific for either type of lesion.

Two types of bacteria were isolated from a single specimen which had recently died; one from a lesion, the other from the spleen and kidney. The spleen and kidney bacteria were recovered in practically pure culture and from growth characteristics appeared identical. While there was the usual conglomerate of colonial growth from the lesion, there was a marked predominance of the bacteria type studied. Physical and biochemical properties of the organisms indicated the one isolated from the lesion to be *Pseudomonas* sp. and the one from the spleen and kidney to be *Aeromonas salmonicida* (the causative agent of furunculosis). The pathogenicity of both organisms was determined by subcutaneous and intraperitoneal injections of yearling brook trout; massive local reactions occurred at injection sites (subcutaneous) of fish inoculated with *Pseudomonas* sp. prior to their death.

Furunculosis had not been previously reported in a natural population of smallmouth bass (Herman, 1968). Since these fish were brought into a laboratory where a continuous study was being conducted on this disease in trout, it was felt that accidental contamination was a possibility despite ordinary precautions. Subsequently, a study was undertaken in 1970 to determine if trap netting was related to the lesions and furunculosis.

LITERATURE REVIEW

Reports of furunculosis in natural waters are not especially com-

mon, particularly in this country, and the disease generally does not appear to reach epizootic proportions, at least in terms of actual mortality. An exception to this (Buckley, 1969) was the extensive losses involving yellow bass (*Morone mississippiensis*) in Clear Lake, Iowa in May 1968. A severe impact was made on this species only, although other species were present in the lake. Buckley postulated that overpopulation and subsequent nutritional deficiency, proximity to the spawning period, and rising water temperature provided the necessary stress to initiate the epizootic.

Fryer and Conrad (1965) referred to some of the earlier reports of the disease in Oregon waters involving adult coho salmon (*Oncorhynchus kisutch*), rainbow trout (*Salmo gairdneri*) and chinook salmon (*Oncorhynchus tshawytscha*). They presented data acquired since 1961 relative to the isolation of *A. salmonicida* in adult salmon. Although quantitative information was not available, it appeared that epizootic levels were not reached with the possible exception of spring mortality of chinook salmon in the Trask River.

There are other reports of recovery of *A. salmonicida* from fish in natural waters. Rabb and McDermott (1962), in a search made in 10 Ontario (Canada) streams, bacteriologically examined 1,044 fish of assorted species. *A. salmonicida* was found in specimens from two streams. Three brook trout (*Salvelinus fontinalis*) and one mottled sculpin (*Cottus bairdi*) out of 360 fish (243 trout) in one stream, and 37 of 284 brook trout in a second known as Beaver River, harbored the organism. Admittedly, there had been yearling brook trout planted near the section of the Beaver River from which the samples were taken, but these had no known history of furunculosis.

Economon (1960) stated that two male northern pike (*Esox lucius*) were found dead in a spawning pond at Waterville, Minnesota, where they had been placed earlier as brood stock. *A. salmonicida* was isolated from lesions and kidneys of both fish.

More or less of a side issue to the main theme of this paper, but certainly relevant, are the habitat and viability studies pertaining to *A. salmonicida* by Cornick et al. (1969). They attempted to recover the organism from 2,954 vertebrate and nonvertebrate forms of life associated with water from two hatcheries experiencing heavy losses from furunculosis. Also, 70 water and 70 pond-bottom samples were screened in attempts to isolate it. With one possible exception in a snail (*Physa gyrina*), results were all negative. Their viability studies indicated survival of cells for from 17 to 63 days, depending upon environment and temperature. Sterile tap water, heat-sterilized river water, sterile tap water and soil mixture, and sterile moist soil were the media used. The writers felt that pseudomonads frequently recovered from non-sterile pond material and non-trout species might

have restricted the presence of *A. salmonicida* by some antimicrobial process.

McCraw (1952) in reviewing the literature found that *A. salmonicida* was considered an obligate parasite with no power of existing as a saprophyte under natural conditions and that its existence in unsterilized river water was short, a few days at most. This could bear out its possible incompatability with other organisms.

Herman (1968) commented on the increased knowledge of susceptible fish species during the prior 15 years and listed them with accompanying authority. Smallmouth bass was not included in this list.

MATERIALS AND METHODS

The method of study was to net bass in the Wilson Bay area where no commercial fishing was done and place them in a holding net, after which, at different intervals, sample fish were transported to facilities at the Cape Vincent station for further observation and subsequent analysis.

Sampling

Smallmouth bass collected for this study were captured in Oneida Lake trap nets. Two types of trap nets were used, knotted nylon treated with Net Set and knotted cotton treated with Cupernol. The nets were set with 90-foot leaders extending from shore with the car ($6 \times 5 \times 5$ feet) in approximately 10 feet of water. Control fish were captured by angling with barbless hooks and were handled with extreme care.

The nets were set in Wilson Bay off Dablon Point and Baird Point (Figure 1). Three nets were used for collecting bass for the experiments. Nets were tended daily when weather conditions allowed. A knotted cotton scap net was used to tend nets, and all bass were removed and placed in water-filled washtubs for transport to the holding net.

The commercial netting procedure consists of checking nets every other day. This procedure was followed by commercial fishermen in contact with project personnel even before it was required by Department regulation in 1970. Releasing a tied sim on the bottom of the net allows the entire catch to be dropped into the bottom of the boat. The catch is then sorted. Commercial species are separated into wooden boxes or wire baskets, or moved to one end of the boat in the case of eels. Sport fish and others that are not to be kept are then thrown overboard by hand or scooped overboard with a shovel.

In Experiment 1, 65 bass were placed in the holding net on May 21, 1970. Every two days thereafter a sample of 10 fish was removed with a scap net. Every effort was made to insure that each bass in the

net had an equal opportunity of being selected. The fish were then transported in a tank on a truck to the station holding facilities 4 miles away. After 10 days, five groups (2-day, 4-day, etc.) were in the station raceways and tanks. The incidence of damaged fish removed from the holding net appeared to be much less than that observed in the commercial nets.

Experiment 2, begun on May 28, 1970, involved holding other species along with bass to more closely approximate commercial netting conditions. In this experiment, yellow perch (*Perca flavescens*), rock bass (*Ambloplites rupestris*), white suckers (*Catostomus commersoni*), bluegills (*Lepomis macrochirus*) and brown bullheads (*Ictalurus nebulosus*) along with 41 smallmouth bass were placed in the holding net. These bass were then randomly selected and removed in groups of 10, at 2-day intervals, and transported to the station holding facilities as in Experiment 1.

Holding Facilities

The bass transferred to the station averaged 1 to 3 pounds in weight. The experimental fish were held in 2,300-gallon concrete raceways or 700-gallon galvanized tanks. The 10 control fish were held in a 500-gallon galvanized tank. All concrete raceways had smooth limestone gravel spread on the bottom and concrete floor paint applied to the sides.

A shallow reservoir on the station property was used as a water supply for all the holding facilities. Water for the reservoir was pumped from the St. Lawrence River. A steady flow of water was run through all the tanks, which had an inflow pipe at one end and a drain at the other. The flow insured that all tanks would remain relatively clean with similar temperatures and with no stagnation. Temperatures were not recorded on a regular basis, but checks were made to determine the variation in temperature between the tanks and the lake.

Pathological Analysis

Extra aseptic precautions were taken in handling bass brought to the Rome Laboratory from the Cape Vincent station. Dead and moribund fish, as well as reasonably active although lesioned specimens, were examined. Difco Furunculosis Agar was used in identifying *A. salmonicida* colonies. Pathogenicity and physical and biochemical characteristics were determined for at least two separated medium pigmenting isolates to conclude identification.

A second analysis entailed an on-the-spot examination and subsequent innoculation of culture media with suspect tissue from bass held in enclosures at the Cape Vincent station. This approach would

further substantiate the natural occurrence and eliminate possible laboratory bias.

RESULTS

The five groups of smallmouth bass from Experiment 1 and the four groups from Experiment 2 all had some lesioned fish before termination of the tests (duration = 33 days maximum). Six bass from Experiment 1, all alive and lesioned when selected at the Cape Vincent station, were analyzed at the Rome laboratory. Lesions, spleen and kidneys were the tissue types tested, and *A. salmonicida* was present in four of the fish examined (Table 1).

Analysis of a second sample of eight smallmouth bass was conducted at the Cape Vincent station. Seven specimens were selected from among both experimental lots and one was selected from the control group. The lack of moribund or dead bass at this time necessitated sacrificing individuals displaying lesions, and these were scarce because the more seriously afflicted fish had already died. Again, the tissues examined included the spleen, kidney and lesions (Table 2). No lesions were present on the control fish, and a test of the spleen and

TABLE 1. RESULTS OF EXAMINATION OF SMALLMOUTH BASS FROM EXPERIMENT 1 FOR PRESENCE OF *Aeromonas salmonicida*

Bass No.	Condition	Tissue	*A. salmonicida*
1	Live	Spleen and kidney	Present
		Lesion	Present
2	Live	Kidney	Present
3	Dead	Kidney	Present
4	Live	Kidney	Present
5	Live	Kidney	Absent
6	Live	Kidney	Absent

TABLE 2. RESULTS OF EXAMINATION OF SMALLMOUTH BASS FROM BOTH EXPERIMENTAL LOTS FOR PRESENCE OF *Aeromonas salmonicida*

Bass No.	Tissue	*A. salmonicida*
1 *	Spleen and kidney	Absent
2	Spleen	Absent
	Lesion	Absent
3	Spleen	Absent
	Lesion	Present
4	Spleen and kidney	Absent
5	Lesion	Absent
6	Lesion	Present
7	Lesion	Present
8	Lesion	Present

* Control fish.

Table 3. Percentage of Mortality for Smallmouth Bass from Experiments 1 and 2

Group *	Experiment 1	Experiment 2
2-day	10	20
4-day	50	90
6-day	50	60
8-day	70	70
10-day	60	..
Control	0	0

* "2-day group" etc. refers to number of days the bass were held in the holding net prior to transfer.

kidney tissue proved negative. Among the others examined, *A. salmonicida* was present in most of the lesions, but none was found in internal organs.

Mortality from the two experiments ranged from 10 per cent for the 2-day group in Experiment 1 to 90 per cent for the 4-day group in Experiment 2 (Table 3). The control samples had no mortality or lesions at the termination of the experiments on June 23, 1970. The difference in mortality between the control fish and the trap-netted fish was so conclusive that no test of significance was deemed necessary. The mortality data for the two experiments indicate that smallmouth bass held in trap nets for longer periods of time have a greater probability of contracting furunculosis.

A regression line was computed by the method of least squares for the mortality data from both experiments (Figure 2). In Experiment 1 mortality increased at a rate of 7 per cent for each additional day smallmouth bass were held in the net, and in Experiment 2 the average increase was 9 per cent per day. When tested by the *Z*-test (Snedecor and Cochran, 1967), these increases were statistically significant ($P < 0.0004$) in both experiments. With the control group excluded from the regression analysis, the average increase in mortality was 6 per cent in each experiment and was still statistically significant ($P < 0.005$) for the combined results.

CONCLUSIONS

From the pathological examination at the Rome laboratory it appeared that as fish became moribund or expired, as was the case with certain individuals, *A. salmonicida* could readily be recovered from the spleen and kidney, but not prior to this. When *A. salmonicida* was recovered from lesions, it frequently was accompanied by other organisms some of which were *Pseudomonas* sp. This was the case in the study of the single bass made in 1969, and *Pseudomonas* sp. was also isolated in 1970. This organism had previously been unreported because the focus was on *A. salmonicida*. As no organisms other than

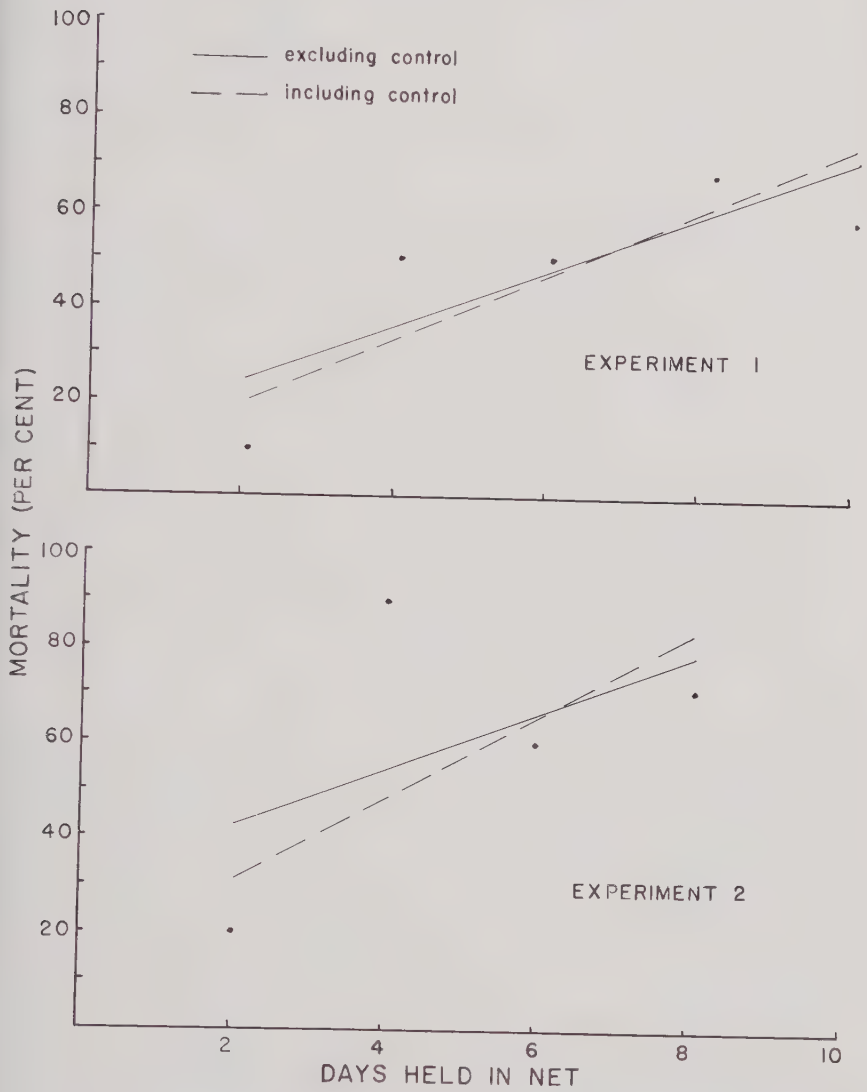

Figure 2. Regression lines of smallmouth bass mortality from Experiments 1 and 2, plotted including and excluding data for control fish.

A. salmonicida were found in the kidneys and spleens of moribund or dead fish, it is evident that *A. salmonicida* was directly responsible for mortality.

The findings indicate that the causative agent of furunculosis can be contracted by smallmouth bass held in trap nets for 2 to 10 days. It follows that the more bass taken and handled by commercial fishermen, the greater the incidence of the disease. Thus, in the Hard-

scrabble area where most of the commercial fishing was done and where the number of bass caught increased substantially after the season was extended to May 28 in 1968, the incidence of subsequent sores on these fish also increased. In Wilson Bay, on the other hand, where no commercial fishing was done, the incidence of sores remained low.

The direct relation between the holding of smallmouth bass and the incidence of furunculosis may prove to be a significant mortality factor with respect to the recreational fishery where large numbers of these bass are handled by commercial fishermen. An attempt was made to estimate the catch in the nets of the two inshore commercial fishermen in the Hardscrabble study area. A total of 5,875 smallmouth bass were counted in a partial sampling of their nets between May 15 and 28 in 1971. Expansion of the data to include bass captured throughout the spring season by these fishermen gives an estimate of over 9,000 smallmouth bass handled.

However, relatively few were caught each year before the season was extended in 1968, and furunculosis was not a problem. The results of this study, therefore, indicate that reverting to May 15 as the closing date for commercial fishing would adequately protect the smallmouth bass fishery in eastern Lake Ontario.

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AGE AND GROWTH OF THE CISCO IN ONEIDA LAKE, NEW YORK[1]

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ABSTRACT

Age and growth determinations were made from scales of ciscoes collected from 1960 to 1970. A false annulus occurred each calendar year during the months of highest water temperature and lowest dissolved oxygen levels. Predominance of ages I and II ciscoes indicated high mortality rates in the population. Possible causes of false annulus formation and the high mortality rate are discussed.

The cisco (*Coregonus artedii*) is a stenotherm generally associated with deep, cold lakes of glacial origin. Cisco lakes in general exhibit a thicker stratum of water below 20° C. than do non-cisco lakes as well as dissolved oxygen levels greater than 3 ppm (Frey, 1955). Shallower cisco lakes tend to have significant photosynthesis occurring near the thermocline, which provides the adequate oxygen levels believed to be an important factor in enabling the cisco to survive in such waters (Frey, 1955). The natural distribution of the coregonid family reaches as far south as the lake district of northern Indiana (Meek, 1916).

The cisco is the only coregonid common in Oneida Lake. Its presence in a shallow eutrophic lake where temperatures exceed 24° C. is unusual and prompted an investigation of the growth and age structure of the population.

Oneida Lake, located in the lake plains region of central New York, has a surface area of 207 square kilometers. Maximum depth is 16.8 meters with a mean of 6.8 meters. Productivity is high, and frequent blooms of blue-green algae occur during the summer months. Thermal stratification is not stable, and mixing of surface and bottom water occurs sporadically during the summer. Temperatures often exceed 24° C. at 2 meters and are above 20° C. in the deeper areas of the lake for extended periods during the summer (Figure 1). Dissolved oxygen concentrations of less than 3 ppm may occur at depths over 9 meters during periods of weak circulation in calm weather (Greeson and Meyers, 1969; Mt. Pleasant et al., 1961).

Over 50 species of warm-water fish have been reported from Oneida Lake. Important sport fish include the walleye (*Stizostedion vitreum*), smallmouth bass (*Micropterus dolomieui*) and yellow perch (*Perca flavescens*). The cisco and burbot (*Lota lota*) are the only species

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[1] Federal Aid in Fish and Wildlife Restoration Project F-17-R contributed the field data for this study. The author wishes to thank Dr. John L. Forney who suggested this study, helped with the data interpretation and critically reviewed the manuscript. Thanks are also due Dr. Richard L. Noble who read the manuscript and offered helpful suggestions.

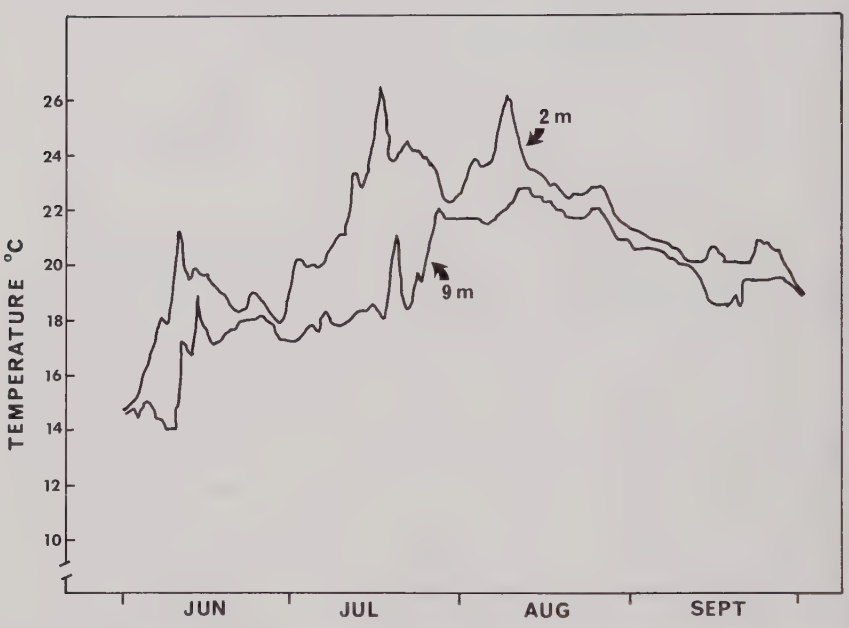

Figure 1. Temperatures at depths of 2 and 9 meters at Shackelton Point (Oneida Lake) during the summer of 1968.

present which are generally associated with more northern waters. The cisco and burbot are frequently attacked by the lamprey (*Petromyzon marinus*) which has been present in Oneida Lake since the late 1800's.

MATERIALS AND METHODS

Young ciscoes were frequently captured in May and June in Miller (1961) high-speed samplers, and young were occasionally caught during late summer in bottom trawls. Most older ciscoes were captured in gill-nets constructed with equal lengths of 1½-, 2-, 2½-, 3-, 3½- and 4-inch stretch mesh. These nets were set at weekly intervals from June to early September and less frequently in the fall.

Scales and measurements were taken from 608 ciscoes collected from June through November from 1960 to 1970. All fish were measured fresh, and their total lengths were recorded to the nearest millimeter. Scales were pressed on cellulose acetate and read on a scale projector with a magnification of 31×. All fish with malformed or regenerated scales were omitted. Determination of age was made twice, and scales were read independently of size of fish to minimize bias. Only fish of ages I and II were used in this study since interpretation of ages beyond age II was speculative because of the crowding of annuli. Lengths were back-calculated by direct proportion (Hile, 1970).

RESULTS

Mean lengths of young ciscoes increased from 12 millimeters in mid-May to 138 millimeters by late October (Figure 2). Young in early May were 8 to 10 millimeters long, and those caught in mid-June in high-speed samplers ranged from 27 to 30 millimeters. Largest catches were generally taken in the upper meter of water column. Young probably remain pelagic during the summer since very few were caught in bottom trawls between July and October. The few young taken in trawls during late October and early November ranged in length from 130 to 150 millimeters.

Length distribution of ciscoes taken in gillnets fished from June through early September generally exhibited two distinct modes (Table 1). From published information on growth of ciscoes, it was assumed that the first mode represented age I+ fish and that those over 280 millimeters were age II+ and older.

Examination of scales from ciscoes between 190 and 280 millimeters long revealed more marks than anticipated. All fish in this length range caught between June and early September exhibited two marks on their scales. A prominent mark was located near the centrum,

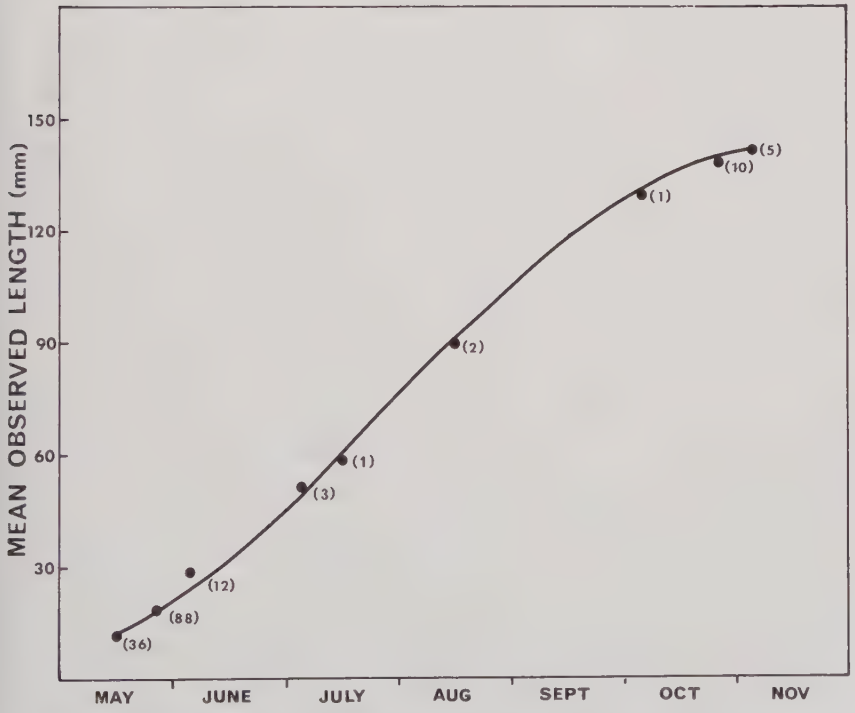

Figure 2. Average growth of young ciscoes caught in Oneida Lake from 1960 to 1970. Number of fish examined shown in parentheses.

Table 1. Length Distribution of Ciscoes Caught in Gillnets in Oneida Lake

Length class in millimeters	Year										
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
190-194	..	..	..	..	..	..	1	..	..	..	..
195-199	..	..	..	..	..	..	4	..	..	1	..
200-204	..	..	1	1	..	1	6	..	..	1	..
205-209	..	..	..	1	..	1	6	..	..	4	..
210-214	..	..	..	..	..	2	11	..	2	6	..
215-219	..	..	..	..	..	3	5	1	..	7	1
220-224	..	..	..	..	2	1	5	..	..	2	..
225-229	..	3	..	..	2	2	1	..	2	5	..
230-234	..	2	..	2	..	4	1	..	2	1	..
235-239	..	1	..	1	..	2	..	..	1	..	..
240-244	..	2	..	..	1	1	..	..	3	..	..
245-249	..	..	..	..	..	4	..	..	..	1	..
250-254	..	..	..	1	..	1	..	..	2	..	1
255-259	..	..	..	2	1	..	..	..	2	1	..
260-264	..	..	..	..	1	..	..	..	..	..	..
265-269	..	..	..	..	..	..	..	..	..	..	..
270-274	..	..	..	..	..	..	..	..	..	..	..
275-279	..	..	..	..	..	..	..	..	..	..	..
280-284	2	..	1	..	..	1	2	1	..	1	..
285-289	..	..	..	1	2	..	..	..	..	..	..
290-294	2	..	2	..	1	..	6	..	..	1	1
295-299	3	..	3	1	..	1	2	2	..	..	3
300-304	6	..	1	1	2	1	1	3	..	2	1
305-309	1	1	2	1	2	2	1	2	..	4	6
310-314	5	..	2	..	2	2	2	2	..	4	6
315-319	3	..	..	1	4	2	..	3	..	1	8
320-324	2	..	..	1	5	6	..	1	1	3	13
325-329	2	2	..	9	4	3	..	..	..	..	8
330-334	3	2	1	1	..	4	2	..	4	1	11
335-339	1	1	..	8	8	5	..	1	3	..	5
340-344	1	..	1	4	1	5	1	1	1	1	8
345-349	1	..	..	2	4	5	1	..	4	1	4
350-354	1	2	1	1	3	2	..	1	5	2	6
355-359	..	3	..	5	4	2	1	..	2	4	3
360-364	..	2	..	..	2	3	1	..	3	4	4
365-369	..	..	..	1	5	2	..	2	3	1	3
370-374	..	..	..	1	1	3	..	..	1	1	3
375-379	..	..	1	1	1	1	..	..	..	1	3

and a less distinct but readily identifiable mark was discovered two-thirds the distance between the centrum and the scale margin. Back-calculated lengths for the second mark ranged from 127 to 150 millimeters and corresponded to observed lengths of young in the fall indicating that it was probably a valid annulus.

Fish from the 190- to 280-millimeter size range collected after September exhibited a third mark on the scales. The presence of this mark suggested that a false annulus was also formed during the second summer. This interpretation of the scale markings was verified by comparing calculated lengths at each mark (Table 2) with observed lengths of ages I and II fish (Table 3). Calculated lengths at markings interpreted as the first and second annuli bracket the first mode of the

TABLE 2. MEAN CALCULATED LENGTHS (IN MILLIMETERS) AT TRUE AND FALSE ANNULI OF CISCOES FROM ONEIDA LAKE *

Year class	Annulus			
	I	I+ (false)	II	II+ (false)
1963	149.2 (26)	229.2 (26)	282.9 (26)	315.5 (8)
1964	141.5 (43)	227.9 (28)	259.1 (17)	276.0 (3)
1965	127.5 (51)	194.6 (12)	261.0 (10)	..
1966	142.5 (2)	237.0 (1)	295.0 (1)	..
1967	144.5 (26)	235.0 (12)	275.6 (12)	299.6 (2)
1968	137.5 (47)	220.3 (22)	275.4 (19)	307.7 (35)
1969	146.0 (1)	..	..	..
Mean	141.2	224.0	274.8	299.6

* Number of fish given in parentheses.

TABLE 3. MEAN OBSERVED LENGTHS (IN MILLIMETERS) OF AGES I AND II CISCOES COLLECTED FROM ONEIDA LAKE FROM JUNE TO EARLY SEPTEMBER *

Year class	Age I	Age II
1963	..	330.5 (26)
1964	224.8 (22)	296.1 (15)
1965	208.6 (40)	303.7 (11)
1966	216.0 (1)	324.0 (1)
1967	238.0 (14)	301.9 (15)
1968	214.2 (29)	316.7 (65)
1969	232.5 (2)	..
Mean	222.3	312.3

* Number of fish given in parentheses.

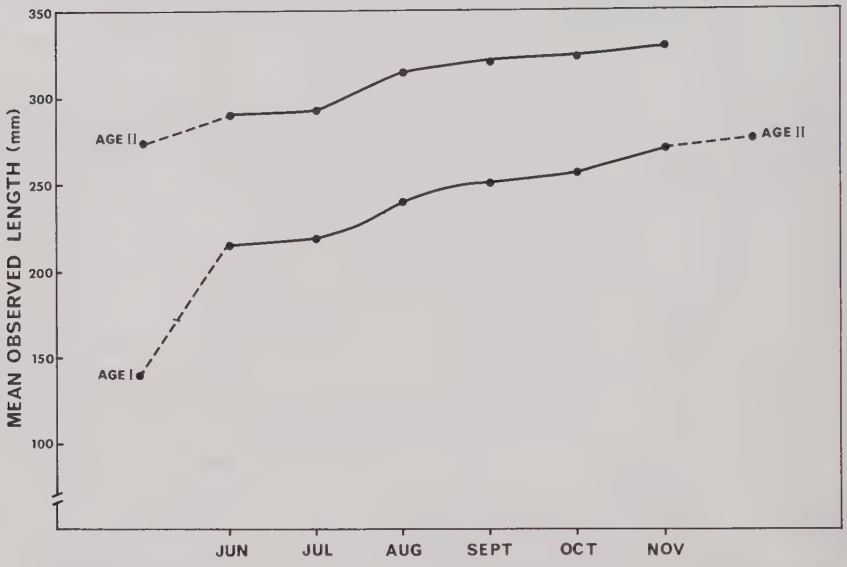

Figure 3. Seasonal distribution of growth estimated from observed and calculated lengths of ages I and II ciscoes collected from Oneida Lake from 1960 to 1970. Initial values in each case, and final value for series beginning as age I, are calculated.

length distribution (Table 1) as anticipated. The similarity between mean observed lengths of ages I and II ciscoes (Table 3) and calculated lengths at the false annuli (Table 2) verifies that these marks are formed in midsummer.

Formation of the false annulus is probably associated with a reduction or interruption of growth in midsummer. A composite of the growth pattern was constructed by pooling all available data (Figure 3). Growth of ages I and II fish was rapid in the spring, decreased in early summer and accelerated in late summer and early fall. Growth studies of ciscoes in other waters reveal growth pattern unlike the type exhibited by the cisco in Oneida Lake. In Lake Superior, the most rapid growth occurred in June (Dryer and Beil, 1964). Growth was greatest in July in Lake Michigan (Smith, 1956), and in Lake Nipissing (Ontario) Fry (1937) indicated most of the growth occurs in spring and early summer. Although growth is interrupted during midsummer, length of ciscoes in Oneida Lake at the second annulus was greater than that reported by Carlander (1969) for other populations.

Males predominated in most gillnet samples (Table 4). Among age III and older fish, the catch of males was significantly greater than that of females, assuming a 1:1 ratio ($\chi^2 = 4.07$, $P < .05$).

Most ciscoes caught in gillnets were ages I+ and II+ fish. Only 28 per cent of the catch was over age II. This was much lower than the

TABLE 4. NUMBER OF MALE AND FEMALE CISCOES CAPTURED IN GILLNETS IN ONEIDA LAKE

Age and sex	Year											Total
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1709	
Age I												
Male	0	4	1	5	4	13	24	1	6	9	1	68
Female	0	4	0	4	3	9	16	0	8	20	1	65
Age II												
Male	14	5	4	9	12	16	8	5	0	7	47	127
Female	16	1	7	17	11	10	7	6	1	8	18	102
Age III & older												
Male	3	4	2	2	14	19	3	6	12	11	20	96
Female	0	3	2	10	14	5	2	2	14	6	12	70

proportion found in most populations (Carlander, 1969) that have been studied and suggests a high mortality of older fish.

DISCUSSION

The reduction or interruption in growth indicated by the false annuli may be associated with high summer temperatures. Temperatures in Oneida Lake increase rapidly in June and surface temperatures are generally between 22° and 26° C. in July and August as illustrated by records for 1968 (Figure 1). Temperatures in deep water increase slowly during this period as gradual mixing of surface and deep water occurs. Figure 1 shows that the period of decreased growth of ciscoes from June to July corresponds reasonably with the period when temperatures are over 20° C. in the lower depths. Dissolved oxygen at these lower depths is often below 3 ppm which forces ciscoes into the warmer surface layers. Temperatures in Oneida lake exceed 20° C. which Frey (1955) suggested as the upper physiological limit for the cisco. Reduction in food intake and growth of some species has been observed at temperatures approaching their upper tolerance level (Warren and Davis, 1967).

Cisco die-offs are observed each summer with most of the loss occurring in late June and July. All fish in the die-off are over 200 millimeters long, and most are age II and older. In a southern Michigan lake, Colby and Brooke (1969) observed similar age-specific die-offs. They attributed the survival of young to higher temperature tolerance and more rapid acclimation to rising temperatures in the summer. However, in Oneida Lake the relation between temperature and mortality is tenuous, since most dead and dying ciscoes have been attacked by lampreys.

Lamprey wounds were observed on 171 ciscoes in a sample of 210 examined in the early summer in 1967, and lampreys were occasionally

found attached to dying ciscoes. Since few dead ciscoes were seen in the spring and fall, attacks must have been more frequent in early summer or ciscoes are more likely to succumb following attacks during this period. The latter explanation seems reasonable since ciscoes are probably subject to stress caused by rising temperatures at that time. Scars are common on large ciscoes indicating that some survive lamprey attacks under favorable conditions.

Favorable conditions for survival of eggs and young are probably responsible for the continued existence of the population in a marginal habitat. Fry are common in May, and young do not appear in summer die-offs. In laboratory experiments, Edsall and Colby (1970) found that young-of-the-year ciscoes can withstand temperatures about 6° C. higher than can adults. These data agree well with the findings of Frey (1955) and Kennedy (1941) who discovered a higher temperature tolerance among young coregonids in nature compared with that of adults.

Ciscoes were of greater importance to the fisheries of Oneida Lake in the past. In the early 1900's ciscoes were propagated. Scriba (1910) reported that 6,000,000 cisco fry were planted in the lake during 1910. Another 8,774,000 fry were stocked in 1912 (Miller, 1912). Eggs were obtained from ciscoes caught in the lake, and the fry were reared at the hatchery at Constantia (N.Y.). The stocking program apparently reflected an interest in establishing a copious population to sustain commercial fisheries that operated on the lake. Annual harvests of 4 to 5 tons of ciscoes were common during this period (Adams and Hankinson, 1916). However, stocking was discontinued before 1928 (Adams, 1928), and there has been no further propagation of the cisco for Oneida Lake. The extensive propagation of ciscoes along with the harvest by commercial fishing are evidence that a larger population was present in the first few decades of the century. The catch of only 608 ciscoes in 150 gillnet sets (200-yard net) from 1960 to 1970 demonstrates that the present population is considerably smaller than that which sustained the commercial fishery.

Summer mortality and lamprey predation on ciscoes were noted in the early 1900's (Bean, 1910; Adams and Hankinson, 1916). Whether mortality from these sources has increased in recent years is unknown. Gradual deterioration of the environment may have contributed to the decline in the cisco population. Oxygen deficits in deep water are probably a recent phenomena since chironomids have replaced mayflies as the dominant component of the benthos in the last decade (Jacobsen, 1966). Low oxygen in the deeper, slightly cooler water may have imposed additional stress on the adult population which is living at temperatures near their upper tolerance level.

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GENERAL NOTES

DERMATOPHILOSIS (CUTANEOUS STREPTOTHRICOSIS) IN A WHITE-TAILED DEER FAWN[1]

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Dermatophilosis is an exudative dermatitis caused by the fungus *Dermatophilus congolensis* and has been reported from wildlife, domestic animals and man. It was first described in cattle in the Belgian Congo (Van Saceghem, 1915) and has been reported as enzootic in cattle in British West Africa (Chodnik, 1950), Kenya (Plowright, 1956), Nyasaland (Zlotnick, 1955) and Rhodesia (Hudson, 1937). Dermatophilosis has been diagnosed in cattle in Australia (Albiston, 1933) and Great Britain (Stableforth, 1937).

In Africa, the giraffe (*Giraffa cameleopardalis*), Thomson's gazelle (*Gazella thomsonii*) and a zebra (*Equus* sp.) have been found infected in the wild (Mackenzie and Simpson, 1956; Green, 1960), but there is no evidence of the severe or fatal infections that sometimes occur in cattle. *Dermatophilus* was isolated from lesions on the nose of two young chamois (*Rupicapra rupicapra*) in Switzerland (Nicolet et al., 1967), and Austwick (1969) reported it from crust-like lesions on the ears of a fox (*Vulpes vulpes*) in Great Britain.

The disease was first recognized in North America when it was reported from two calves from two separate herds in central Texas (Bridges and Romane, 1961). After this initial finding, dermatophilosis was diagnosed in a white-tailed deer (*Odocoileus virginianus*) and in men who handled the carcass in New York (Dean et al., 1961). Horses were found infected in New York and Vermont (Bentinck-Smith et al., 1961), and cattle in Iowa (Pier et al., 1963), Kansas (Kelly, 1964), Kentucky (Pier et al., 1964), Florida (Tucker, 1966) and Mississippi (DiSalvo et al., 1969). The infection was also reported from a captive Columbian ground squirrel (*Citellus columbianus columbianus*) in Ontario (Wobeser and Gordon, 1969). This note reports a *Dermatophilus* infection in a white-tailed deer fawn, and it appears to be the third report of dermatophilosis in North American wildlife and the second from white-tailed deer in New York.

In June 1971, Conservation Officer Gerald Austin confiscated an approximately 15-day-old male fawn from a home in Claverack, Columbia County, New York. The fawn was said to have been given to the family by someone who picked it up along a road near Boston Corners in Columbia County. The fawn had pustules about its eyes and on its ears, nose, lips, hocks, coronary band and the haired regions of the toes. Scattered pustules were present on the back and flanks. The fawn was submitted to the Wildlife Research Laboratory at Delmar for examination.

On examination, the pustules were found to have developed into exudative encrustations (Figure 1) which gave off a foul odor similar to the characteristic smell of sarcoptic mange. The fawn was placed in isolation for further examination. It was approximately 17 days old, weighed 12 pounds and was emaciated. The fawn walked favoring its sore, encrusted feet. Lesions were not present in the oral cavity of the interdigital skin. Scrapings were taken from the skin and cleared in lactophenol solution to check for mites. A biopsy was taken from the nose, fixed in 10 per cent neutral formalin, processed and stained with hematoxylin and eosin stain. The exudate was inoculated on Sabourard, brain-heart infusion and blood agars, and smears of the exudate were stained with Giemsa stain.

The scrapings cleared in lactophenol were negative for mites. The exudate smears, stained with Giemsa and examined under oil immersion, revealed the

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[1] A contribution of Federal Aid in Fish and Wildlife Restoration Project W-35-R. The author is indebted to Dr. Clement Watson of the U.S. Department of Agriculture and William Hesselton of the New York State Department of Environmental Conservation for examining the deer and to Dr. John Debbie, Dr. Morris Gordon and George Little of the New York State Health Department for examining the tissue sections and exudate smears. The author wishes to thank Walter Fogg for the photography of the deer.

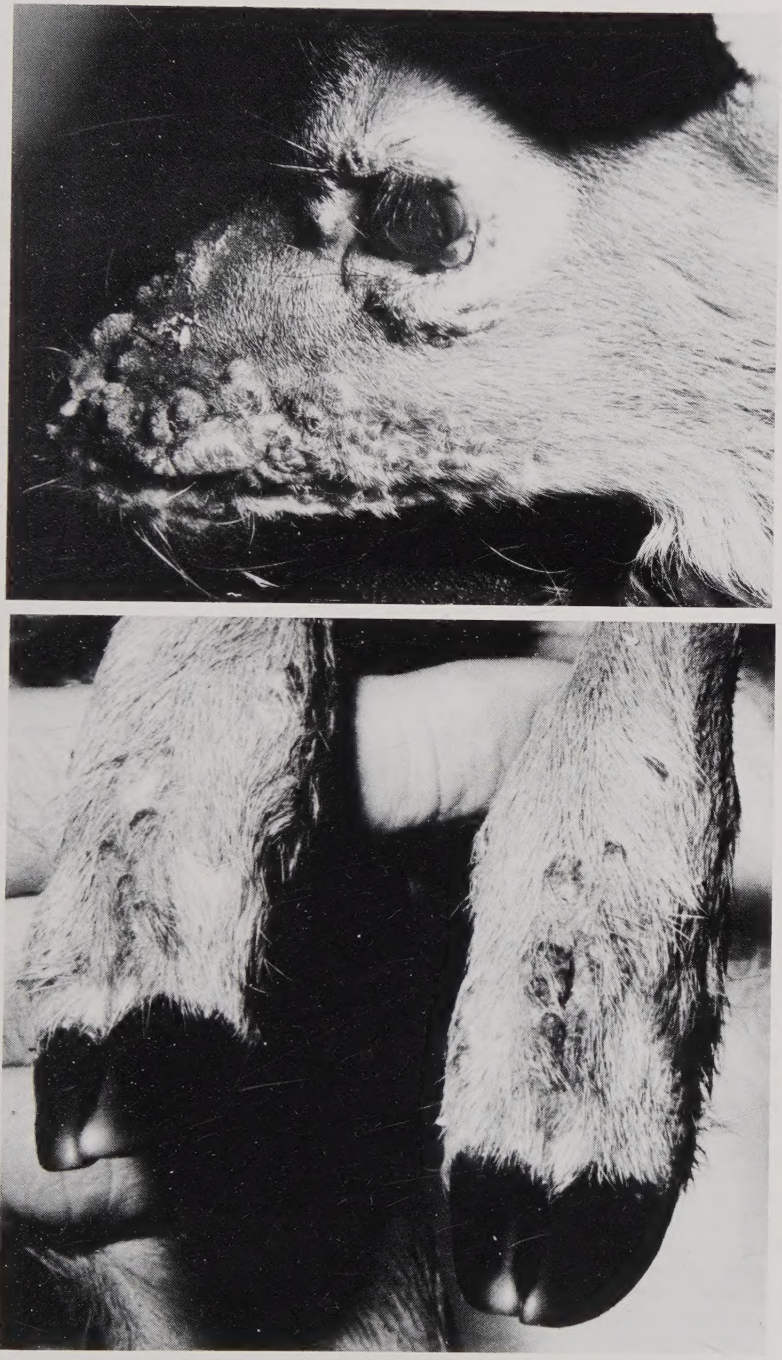

Figure 1. Encrustations on the head (above) and forefeet (below) of a white-tailed deer fawn infected with *Dermatophilus* sp.

presence of branched filaments, characteristic of *Dermatophilus* sp., that divide both transversely and longitudinally to form packets of up to eight coccoid cells. In the hematoxylin and eosin-stained tissue sections, branching hyphae characteristic of *Dermatophilus* were seen. They were present in the thick layer of keratin on the surface of the skin and in microabscesses filled with neutrophils in keratin-plugged hair follicles. The hairs were not invaded by the organism. This histopathology is similar to that seen in cattle by Bridges and Romane (1961).

Dermatophilus failed to grow on Sabourard agar. However, after 48 hours' incubation at 37° C., grayish colonies were present on brain-heart infusion agar and blood agar. Smears of these colonies, stained with Giemsa or Gram's stain, revealed organisms of typical *Dermatophilus* morphology. *Staphlococcus* sp. was also present and quickly took over the cultures.

The fawn was treated by two intramuscular injections, 4 days apart, of 1 cubic centimeter of Longicil S containing 150,000 units of benzathine penicillin G, 150,000 units of procaine penicillin and 0.25 gram of dihydrostreptomycin. Within a week of the first treatment, the fawn was visibly improved and no longer walked favoring its feet. The lesions dried and its appetite appeared normal. Over a period of 6 weeks, the skin regenerated, and there was no evidence of the severe skin infection. *Dermatophilus* could not be cultured or found in smears taken 6 weeks after treatment. The penicillin and dihydrostreptomycin treatment was used because DiSalvo et al. (1969) had used it on cattle in Mississippi and received a favorable response, although they pointed out that the clinical improvement might have been due to spontaneous remission. Dean et al. (1961) reported that a 1½-year-old white-tailed deer exhibited anorexia, depression, loss of weight and dyspnea 15 days after being experimentally infected with *Dermatophilus*. But the lesions disappeared in about 25 days without treatment. In the present case, the penicillin and dihydrostreptomycin may have aided recovery by their effect on the bacterial invaders of the lesions, but there is no proof that these antibiotics had an inhibiting effect on *Dermatophilus*.

The source of infection of this fawn is unknown. The fawn may have been kept with infected domestic stock before being taken to the Claverack home from which it was confiscated. However, the family declined to give detailed information on the deer's history. It is interesting that the first case of dermatophilosis in a white-tailed deer (Dean et al. 1961) came from Orange County, New York, which is about 60 miles southwest of Columbia County.

Considering the large number of veterinarians and wildlife workers in the United States, it is curious that *Dermatophilus* infections were not reported until 1961. One explanation may be that *Dermatophilus congolensis* has been newly introduced from abroad, possibly having been brought in on imported wildlife or domestic animals.

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